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SEASONAL VARIATION IN FOOD, MOUTH ANATOMY, AND DISTRIBUTION OF ADULT YELLOW PERCH (*PERCA FLUVIATILIS FLAVESCENS*) AND YELLOW WALLEYE (*STIZOSTEDION VITREUM VITREUM*) IN LAC STE. ANNE

by

© OTTO E. LANGER

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "Seasonal Variation in Food, Mouth Anatomy, and Distribution of Adult Yellow Perch (*Perca fluviatilis flavescens*) and Yellow Walleye (*Stizostedion vitreum vitreum*) in Lac Ste. Anne" submitted by Otto E. Langer, in partial fulfilment for the degree of Master of Science.

ABSTRACT

Seasonal variations in food type, feeding anatomy, and distribution of adult Yellow perch and Yellow walleye were investigated. Study specimens were collected throughout the year from a euthrophic lake by means of gillnetting.

Stomach contents, measurements of body and jaw components, and catch effort were tabulated to detect seasonal modifications that may enable these two species to feed on a wide range of food organisms.

With the onset of summer, both species exhibited intense feeding activity and mouth components such as tooth length, toothed area, and mouth size increased to maximum size. During fall and winter, food intake decreased greatly and most components of the feeding anatomy decreased to a minimum size.

A study of seasonal distribution patterns helped explain the presence of certain food organisms in each species' diet. Generally, both species preyed upon the most seasonally abundant food organisms and were usually caught in greatest numbers where these food organisms lived. However, their seasonal movements could not be directly related to the pursuit of food organisms.

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I. INTRODUCTION

Fish, like all heterotrophic animals, require injested food to supply energy for life processes. To meet energy demands, fish can consume a range of food types unmatched by that of any other vertebrate group. Their temporal and spatial food habits are also highly variable [Nikolsky, 1963].

Temporal variation of food habits may be due to either ontogenetic or seasonal changes or a combination of both. Ontogenetic development of the feeding apparatus facilitates predation on an optimal size-caloric yield food combination. Correlations between food type and stages of ontogenetic development have been documented for a number of species by Vasnetsov [1948], Pillay [1953], Chandy and George [1960], Yasuda [1960c]. Hynes [1950], Maki [1964], Keast [1968a], and Bellinger and Avault [1971] found a relationship between fish lengths of various species and their respective food sizes but no one explained this relationship in terms of ontogenetic changes in the feeding apparatus. Since ontogenetic variation is difficult to distinguish from other types of morphological variation, most workers attempt to eliminate ontogenetic allometric effects by studying fish of a limited size range [Koehn and Minckley, 1965].

Although numerous studies show that seasonal changes in fish food habits are common, most studies are restricted to the warm seasons [Parsons, 1950; Eschemeyer, 1950; Keast, 1968a). However,

a few studies have determined winter food [Moffett and Hunt, 1943; Hasler, 1945; Keast, 1968b]. Annual cycles have been studied by Pearse and Achtenberg [1920], Hynes [1950], Reed and Bear [1966].

Keast [1965], Wolfert [1966], Houde [1967], and Parsons [1971] have shown that seasonal differences in the food habits of fish are related to changes in available food supply. Only a few ichthyologists have attempted to relate morphological change in the feeding apparatus to seasonal changes in food type. Minor differences in mouth width have been shown to correlate with different foods eaten by trout [Hartman, 1958] and two species of cottids [Northcote, 1954]. Parker and Boeseman [1954] and Hardy [1959] have shown that the Basking shark (*Cetorhinus maximus*) loses its gill rakers after the summer plankton season and resorts to bottom feeding in the winter. Luther [1962, 1964] has shown that two species of Grey mullet, (*Liza macrolepis* and *Mugil cephalus*) shed their gill raker processes coincidentially with seasonal changes in food type. Trautman and Hubbs [1935] could not document the widely held belief that the late summer food habits of Northern pike (*Esox lucius*) are related to changes in the feeding anatomy. Schwartz and Dutcher [1962] documented a constant tooth replacement pattern in the cyprinid *Notropis cerasinus* but did not think it correlated with a seasonal change in the food habit.

Intraspecific spatial variation in fish diets is very common [Nikolsky, 1963, 1969]. Applegate and Mullan [1967a, 1967b], have shown that such variation is due to differences in available food. Many fish are opportunistic feeders using whatever suitable food

is most plentiful [Walburg, Kaiser and Hudson, 1971; Ivanova, 1969]. It is not clearly understood what enables a species to efficiently feed upon different food types in different areas. Kozikowska [1961] maintains that the feeding apparatus of whitefish are unspecialized and are too plastic, temporally and spatially, to attribute any genetically controlled differences to different populations. In the same study, she documents different diets and gill filter densities for perch sampled from lakes differing in trophic condition.

Thus, where obvious changes in a fish's feeding apparatus have been documented, a marked change in food habit also occurs. Differences in the feeding apparatus which are not obvious can also account for marked differences in the food types consumed by a species.

In this study, I postulated that fish that seasonally consume different foods must also undergo a seasonal change in the feeding apparatus to enable efficient feeding. Yellow perch, *Perca fluviatilis flavescens* [Mitchill], and Yellow walleye, *Stizostedion vitreum vitreum* [Mitchill], were studied to demonstrate this phenomenon. The spatial intraspecific food habits of these species are similar [Eschmeyer, 1950; Keast and Webb,1966] yet they do exhibit seasonal food change [Pearse and Achtenberg, 1920; Eschmeyer, 1950]. Perch are considered specialized feeders [Keast and Webb, 1966] and their relative morphological variation is genetically limited [Kozikowska, 1961].

In addition, seasonal distribution of both species was studied to determine seasonal movements and fish location relative to the known distribution of certain food organisms.

II. MATERIALS AND METHODS

Two subspecies of Percidae, the Yellow walleye, *Stizostedion vitreum vitreum* [Mitchill], and the Yellow perch, *Perca fluviatilis flavescens* [Mitchill], were investigated in this study. In North America, the latter subspecies has commonly been given the species status of *Perca flavescens* [Mitchill] but its similarity to the European form, *Perca fluviatilis* Linnaeus, does not warrant this separation [Berg, 1949; Nikolsky, 1954; Weatherley, 1963; Mansueti, 1964].

Collection of material began May 30, 1968, and continued until June 17, 1969. The data were divided into seven two month periods beginning with the May-June period of 1968. For reference purposes each seasonal period was given a number and seasonal description (Table 1). All samples were collected from Lac Ste. Anne where the University of Alberta's Lac Ste. Anne Fish Research Laboratory was used as a field station.

A. Description of Lac Ste. Anne

1. General

Lac Ste. Anne is a relatively large eutrophic lake located 74 km west-northwest of Edmonton with a geographic location approximately 114° 24'W longitude and 53° 43'N latitude (Department of Mines and

TABLE 1 Dates, reference numbers, and descriptions of the seven seasonal periods into which the study was divided.

Seasonal Period	Reference Number	Description
May 30 to June 30, 1968	1	Spring
July 1 to August 31	2	Summer
September 1 to October 31	3	Fall
November 1 to December 31	4	Early Winter
January 1 to February 28, 1969	5	Mid Winter
March 1 to April 30	6	Late Winter
May 1 to June 17	7	Spring

Mineral Topographical Series, Map Sheet 83G/9 West, Onoway). The lake is situated in a relatively small Aspen Parkland drainage basin. A seasonal stream, the Sturgeon River, flows through it (Figure 1). The discharge of this stream decreased from moderate flow in the spring of 1967 to minimal flow in 1968. No flow was evident in 1969.

The lake consists of three basins joined by two narrow channels of water (Figure 1). It covers an area of approximately 57 km^2 and has an average depth of 4.8 m [Department of Water Resources Hydrographic Survey of Lac Ste. Anne, June, 1965).

Proceeding from the easterly to the westerly most basin, a decrease in basin size and depth, and an increase in degree of eutrophication occurs. The deepest portion of the west basin is less than 2 m and the littoral zone extends completely across the basin. The bottom is composed of organic sediment. This portion of the lake was inaccessible and was not considered as part of the study area.

The maximum water depth in the central basin is approximately 7 m. The bottom is mainly organic sediment except for certain shore areas which are composed of sand and rock (Table 2). The water in this basin undergoes greater winter oxygen depletion than the larger eastern basin. Minimum bottom winter dissolved oxygen concentrations for the two basins were 0.23 ppm and 2.88 ppm respectively.

The majority of collecting areas were situated in the larger eastern basin. The maximum depth in this area is 10 m. Bottom areas greater than 2 m deep are covered mainly with organic sediment. Most of the shore areas have a sand, gravel, or rock bottom and in several offshore areas, rock shoals are present. This area of the lake seemed

Figure 1 Identification of sampling areas of Lac Ste. Anne. The Sturgeon River enters the lake at G1-4 and exits at E20-3. Scale: 14 mm = 1 km.

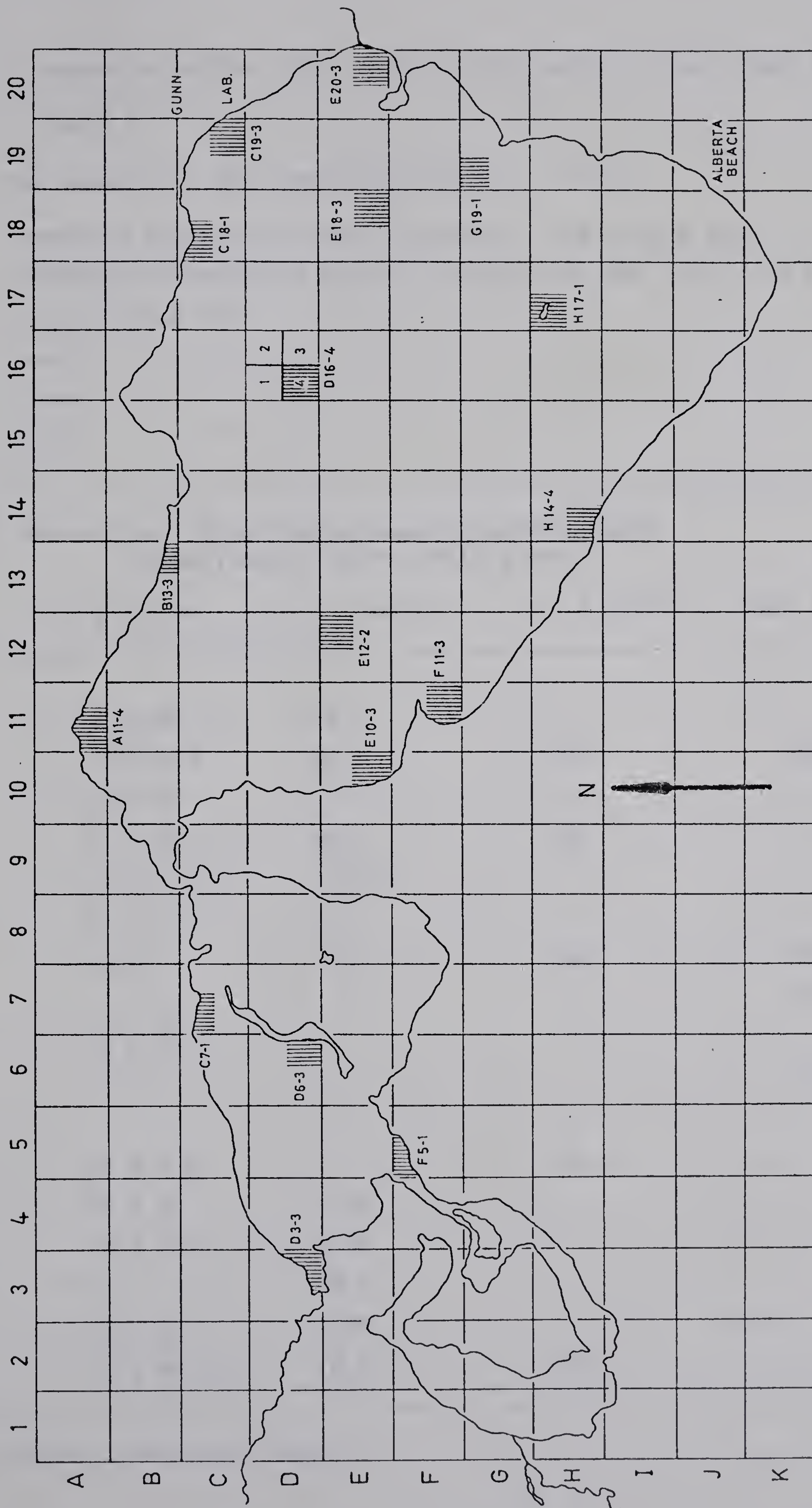

GUNN
LAB.
ALBERTA BEACH
N
A11-4
B13-3
C7-1
C18-1
C19-3
D3-3
D6-3
D16-4
E10-3
E12-2
E18-3
E20-3
F5-1
F11-3
G19-1
H14-4
H17-1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
A B C D E F G H I J K

TABLE 2 Summary of bottom types found in the sampling areas shown in Figure 1.

The meaning of the abbreviations are as follows:

EV - emergent vegetation (usually *Thypa* sp. and *Scirpus* sp.)
V - submergent vegetation (usually *Potamogeton* spp. and *Chara* sp.)
OM - organic rich mud
S - sand
G - gravel
R - rock

Area	Generalized bottom types found at certain depth zones found in each sampling area			
	0 - 2 metres	2 - 4 metres	4 - 6 metres	Over 6 metres
A11-4	EV V OM	OM		
B13-3	EV V OM R	OM	OM	OM
C7-1*	EV V OM			
C18-1*	EV V OM S R G	OM S	OM	
C19-3	EV V OM S R	V OM R		
D3-3	EV V OM	OM		
D6-3	EV R G	OM R	OM	OM
D16-4				OM
E10-3*	EV V OM S			
E12-2*				OM
E18-3			OM	
E20-3	EV V S R		OM R	
F5-1	EV V OM	V OM		
F11-3*	EV V OM S	V OM		
G19-1	R	OM R		
H14-4*	EV V OM	V OM		
H17-2	EV V OM S R	OM S R	OM	

*areas omitted from winter sampling

to be the least eutrophic because algal blooms were less intense, water was clearer, and oxygen depletion was not as severe as in the central basin.

In addition to perch and walleye, the study area contains: Northern pike (*Esox lucius*), White sucker (*Catostomus commersoni*), Burbot (*Lota lota*), Lake whitefish (*Coregonus clupeaformis*), Spottail shiners (*Notropis hudsonius*), Iowa darters (*Etheostoma exile*), and Brook stickleback (*Culaea inconstans*). All species were caught in large numbers except Iowa darters and Brook stickleback.

2. Description of Study Areas

(a) Sampling Areas

Identification of collecting areas was facilitated by gridding the lake into 0.65 km^2 units (Figure 1). The north-south position of a unit is given by a letter and the east-west position is given by a number. Each unit was further subdivided into quarters and numbered as in collecting area D16-4 (Figure 1).

All material was collected in 17 selected sample areas (Figure 1). These were chosen because they represented several water depths and exhibited a variety of bottom types. Also, they were selected to avoid areas where anglers and boats tended to congregate. An Ekmann dredge and visual observations under clear water conditions were used to describe the bottom types of each sample area (Table 2). Seasonal temperature and winter dissolved oxygen concentrations were measured

at as many sampling areas as possible. Dissolved oxygen was determined by the azide modification of the Winkler method (Anon., 1960).

(b) Depth Zones

A bathymetric map of Lac Ste. Anne (Figure 2) shows four depth zones. The three depth contours were drawn at two metre depth intervals beginning at the shore and extending out to a depth of 6 m.

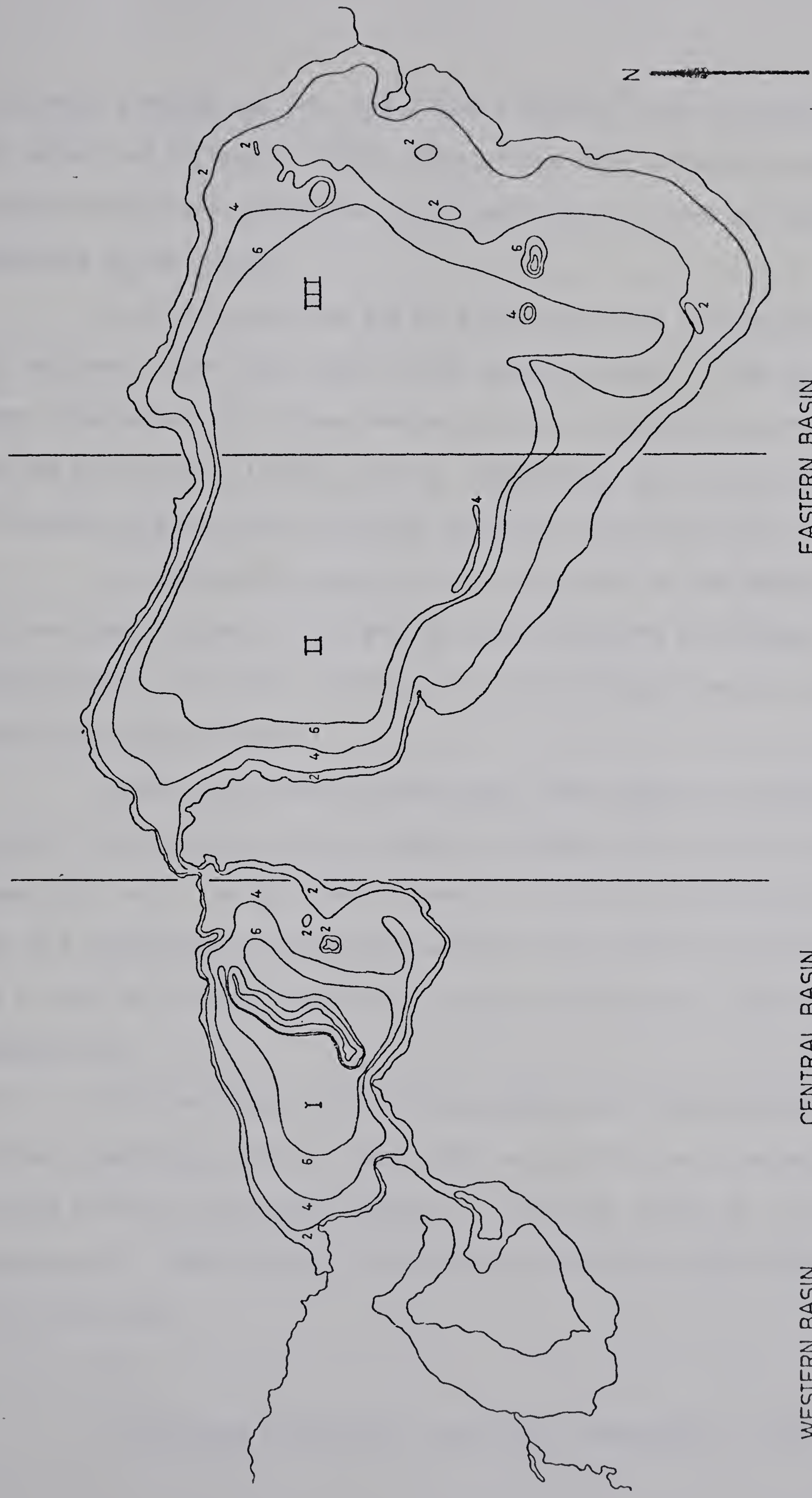
The eastern and central basins were divided into three areas (Figure 2). These areas were determined by drawing a north-south transection every 4.84 km along an east-west transection of the lake. Area I contained the central basin of the lake and thus was the most eutrophic study area. Areas II and III were mainly in the eastern basin and were less eutrophic than Area I.

B. Collecting Methods

During the ice free portion of the year several collecting methods were employed, however, gill nets were primarily used. Three stretched mesh sizes (12.7, 25.4, and 38.1 mm) of monofilament gill net and two sizes (63.5 and 108.0 mm) of multifilament gill net were used. The monofilament nets each had an area of 19 m^2 except the 12.7 mm mesh size net which had an area of 36 m^2. The multifilament nets each had an area of 90 m^2.

Other collection techniques included the use of a large experimental trap net [Lagler, 1956], several minnow traps, a seine,

Figure 2 A bathymetric map of Lac Ste. Anne showing the division of the lake into four depth zones and three lake areas. Depth contours are indicated in metres. Scale: 14 mm is equivalent to 1 km.


N
EASTERN BASIN.
CENTRAL BASIN.
WESTERN BASIN.
III
II
I
2
4
6

dip nets, a nekton tow net, and a Type V Shocker[1] much like that described by Patten and Gillaspie [1966]. Most of the above methods were not effective or would not provide consistent results during all seasons when operated by one person.

Gill nets provided the most consistent and systematic means of catching a wide size range of most species present in the lake. However, few Burbot and no Iowa darters or Brook sticklebacks were caught in the gill nets. All data used for determining the distribution patterns of walleye and perch were obtained from fish collected by gill net.

An attempt was made to collect from each of the sample areas at least once a month. This was not possible during the winter; consequently, six of the sampling areas were deleted from the winter sampling program (Table 2).

Many of the samples were caught using different combinations of gill nets although each set usually included a 25.4 and 38.1 mm monofilament gill net. The nets were joined in a series and the depth of the set was determined by taking the average of the depths at the two ends. Of a total of 161 gill net sets, five were floating sets and 156 were bottom sets.

Gill nets were not set at any particular time of the day nor for any specified length of time. Gill net sets in ice free water varied from one to 66 hours duration. During the period of ice cover (November 11, 1968 to April 29, 1969), the duration of sets varied from 79 to 341 hours.

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[1] Smith-Root Electronics, Vancouver, Washington, U.S.A.

C. Sample Treatment and Analysis

1. Field Treatment

As soon as the walleye and perch were removed from the collecting gear, they were given a sample number, measured and weighed. Most perch and walleye under 20 and 30 cm in length respectively, were preserved whole in ten percent formalin. Of these, some specimens were later measured for length and weighed to check the effects of preservation.

Longer individuals were weighed to the nearest gram and fork length was measured to the nearest millimetre. They were then sexed, and a scale sample was removed from an area ventral to the anterior portion of the lateral line. Scale samples and body measurements were taken from the left side of the animal. The head and stomach were then removed, labelled, and preserved in ten percent formalin. Food material found in the mouth and pharynx was included as stomach contents.

2. Analysis of the Material

Only perch over 20 cm and walleye over 40 cm in fork length were selected for analysis and used as subject material in this study.

(a) Aging

A subsample of 46 walleye were aged by the scale method of Lagler [1956] with the aid of a photographic enlarger [Banks and Irvine, 1969]. These were arbitrarily selected except for the shortest and the longest of the fish studied. From this data, a size range limit was established for each age class and the remaining specimens

were aged by the Petersen method [Carlander, 1969].

A subsample of 30 perch were treated in much the same manner. Because scales were very difficult to read, opercular bones were mainly used to age the fish [LeCren, 1947]. These bones were examined with the photographic enlarger as well as with a dissecting microscope.

(b) Stomach Analysis

All preserved stomachs were soaked in water for 24 hours prior to examination. Before weighing, the stomachs were blotted dry and the fat bodies and connective tissues were removed. Stomach contents were then emptied into a Petri dish of water and identified to the categories listed in Appendix Tables 1 and 2 for walleye and perch respectively. A dissecting microscope was used in all the identifications. The items identified were then enumerated, blotted dry, and weighed.

A computer[2] was programmed[3] to pool the stomach analyses data for each of the seasonal periods for each species . The weight of food in each category was expressed as a percentage of the total stomach contents of each period. This percent weight expression for seasonal periods is similar to that used by Norlin [1967]. Also, the percentage frequency occurrence of each food type, including fish with empty stomachs, was computed for each period by the method of Windell

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[2]IBM Model 360 Series 67.

[3]Programmed in COBOL.

[1968]. Percentage frequency occurrence of food types in perch and walleye captured in each lake area and depth zone was also computed.

The average weight of food per stomach, corrected for seasonal rates of digestion, was taken as an index of intensity of feeding in each seasonal period. Average weights of stomach contents of fish caught in each period, above a 4°C average water temperature, were multiplied by factors obtained from Molnar, Tamassy, and Tolg [1966] which relate digestion rates to higher temperature regimes. They noted that pike-perch digestion is eight times greater at 20°C than it is at 4°C.

(c) Head Anatomy

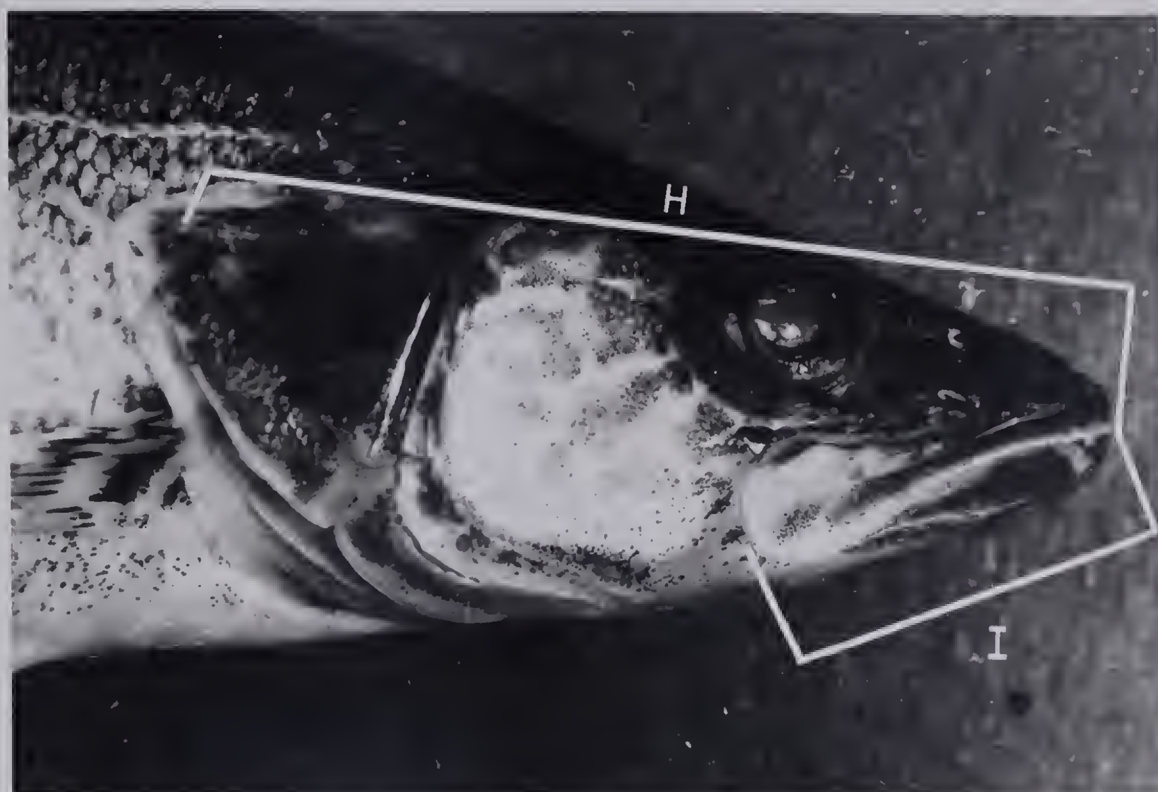
Fish heads were soaked in water for at least 24 hours prior to examination. Mouth indentation and head measurements were then taken as shown in Figure 3. The head length was taken as the distance from the most anterior part of the snout to the posterior tip of the longest opercular spine. The mouth indentation measurement was taken from the most anterior part of the premaxillary to the posterior edge of the maxillary. Width of the mouth aperature was taken as the distance between the inner sides of the articular bones (Figure 4).

Each head was then frontally halved through the buccal and pharyngeal cavities (Figure 5). Gill rakers, on the first left gill arch, that exceeded 0.5 percent of the body length were enumerated and the length of the three rakers closest to the joint of the epibranchial and ceratobranchial elements were measured (Figure 5).

Several measurements were made on the teeth and toothed

Figure 3 Walleye head showing head length (H) and mouth indentation measurement (I). These measurements were taken from perch in the same manner. Magnification: 0.9 actual size.

Figure 4 Perch lower jaw showing dentary toothed area length (D) and mouth width measurement (W). Magnification: 1.9 actual size.


H
I

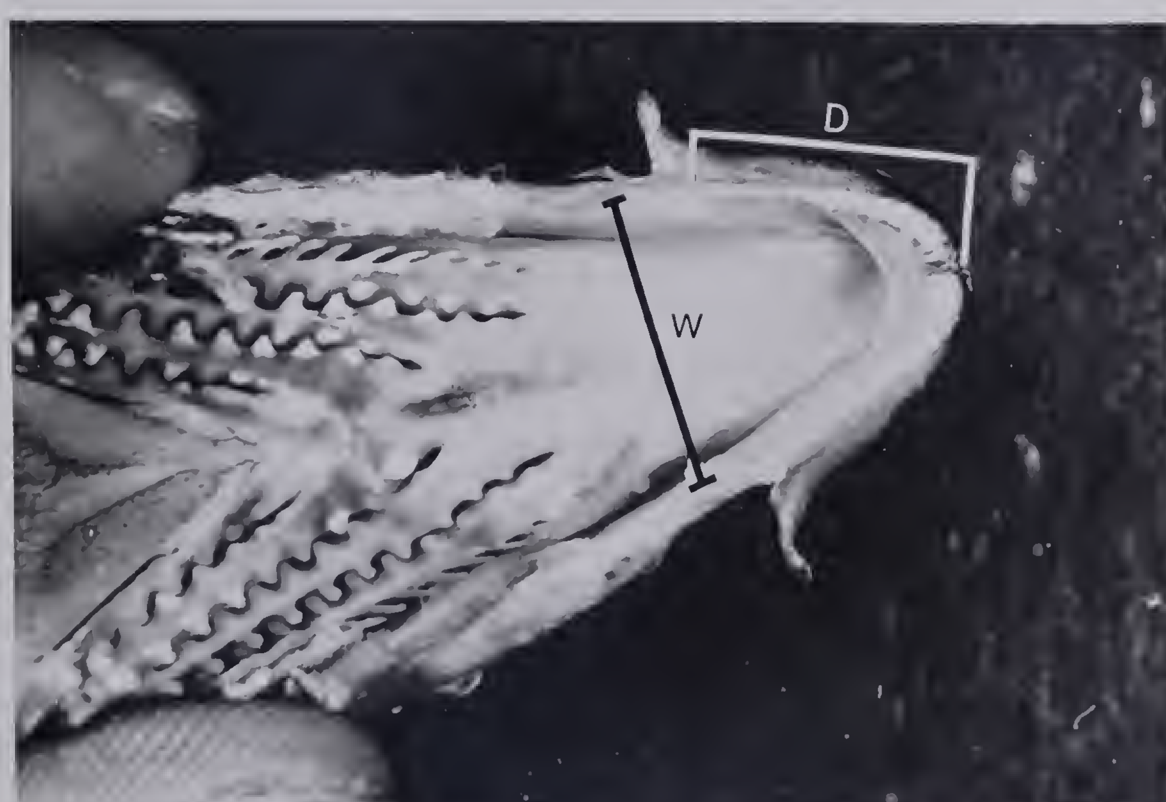
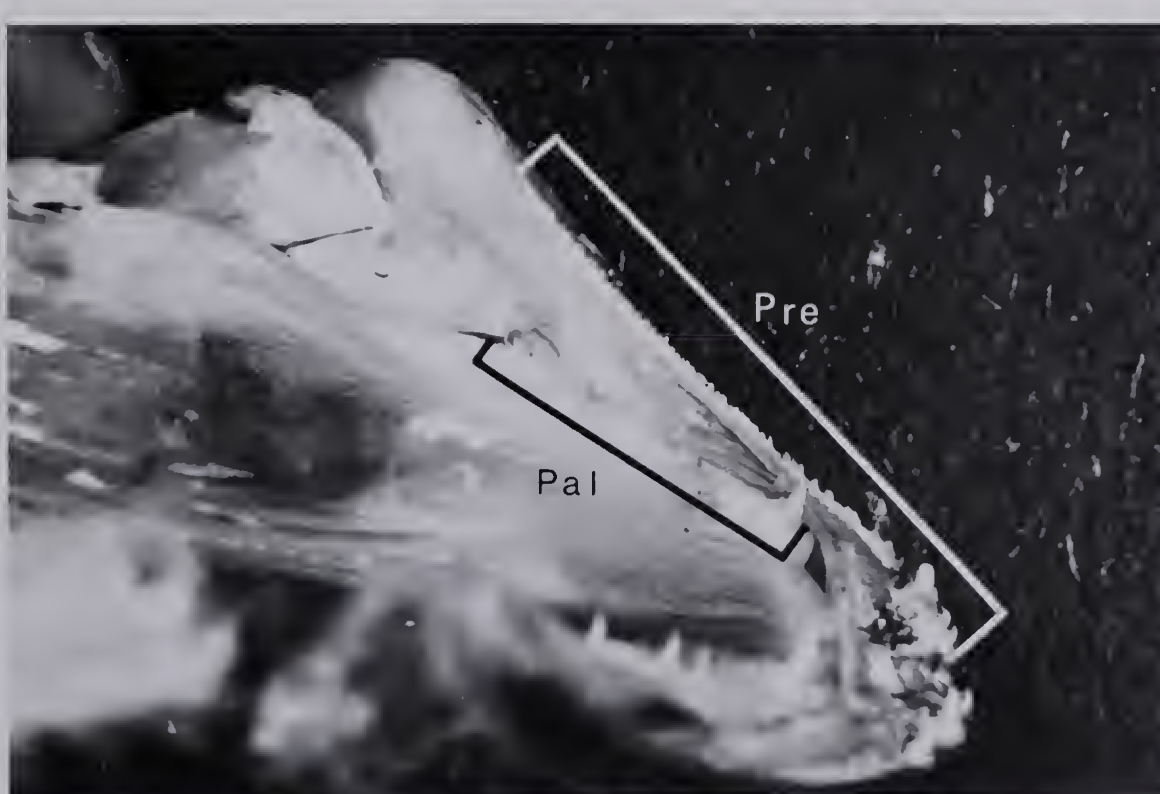
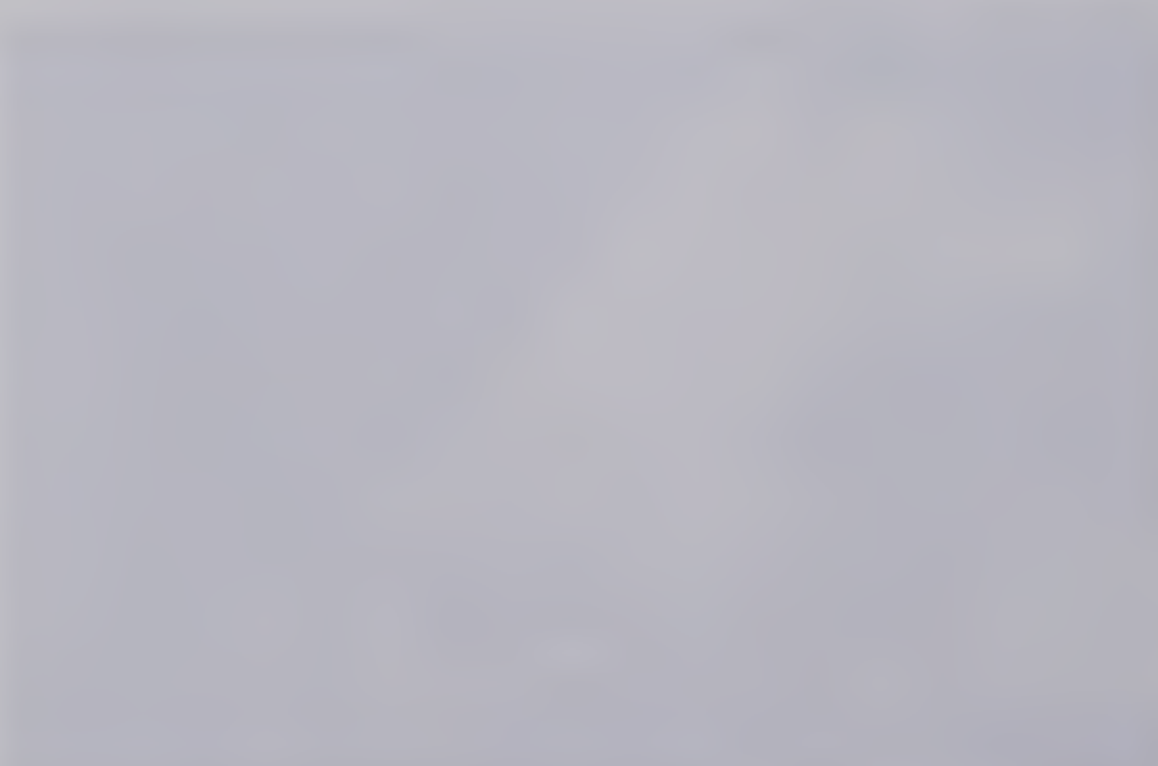

D
W

Figure 5 The ventral half of a walleye head showing the three longest gill rakers measured on the first left gill arch. Dentary teeth are visible on the left. Magnification: 1.3 actual size.

Figure 6 A latero-ventral view of the roof of a walleye mouth showing the lengths of the premaxillary (Pre) and palatine (Pal) toothed areas. The vomer teeth are not evident in this figure. Magnification: 1.9 actual size.


Pre
Pal



areas of the dentary, premaxillary, palatine, and vomer bones of the mouth of each species. The length of the toothed area on each of these bones was measured with a dial micrometer[4] to the nearest 0.05 mm (Figures 4, 6, 7, and 8).

The largest teeth in each toothed area of the walleye were measured by determining lengths of the largest two teeth from the palatine area, four from the dentary, two from the premaxillary, and one from the vomer area. The length of each tooth was taken from its tip to its base. The base of the tooth was found by forcing a sharp edged micrometer into the gingiva surrounding the tooth until it met the alveolar bone supporting the tooth.

The teeth of perch were too small to be measured by the above method. A sample of teeth was scraped off the head of each toothed area with a scalpel (Figure 8). The teeth were then mounted in glycerine between two microscope slides and examined under a compound microscope. Four to six of the largest teeth were selected and measured for length using an ocular micrometer at a magnification of 50X.

The above measurements were repeated on each of a series of perch and walleye and possible variation due to technique was tested by means of Student's paired t-test [Steel and Torrie, 1960].

Measurements of gill rakers and teeth were averaged for each individual fish. These averages and single head measurements (mouth indentation, premaxillary length, etc.) were expressed as a percentage

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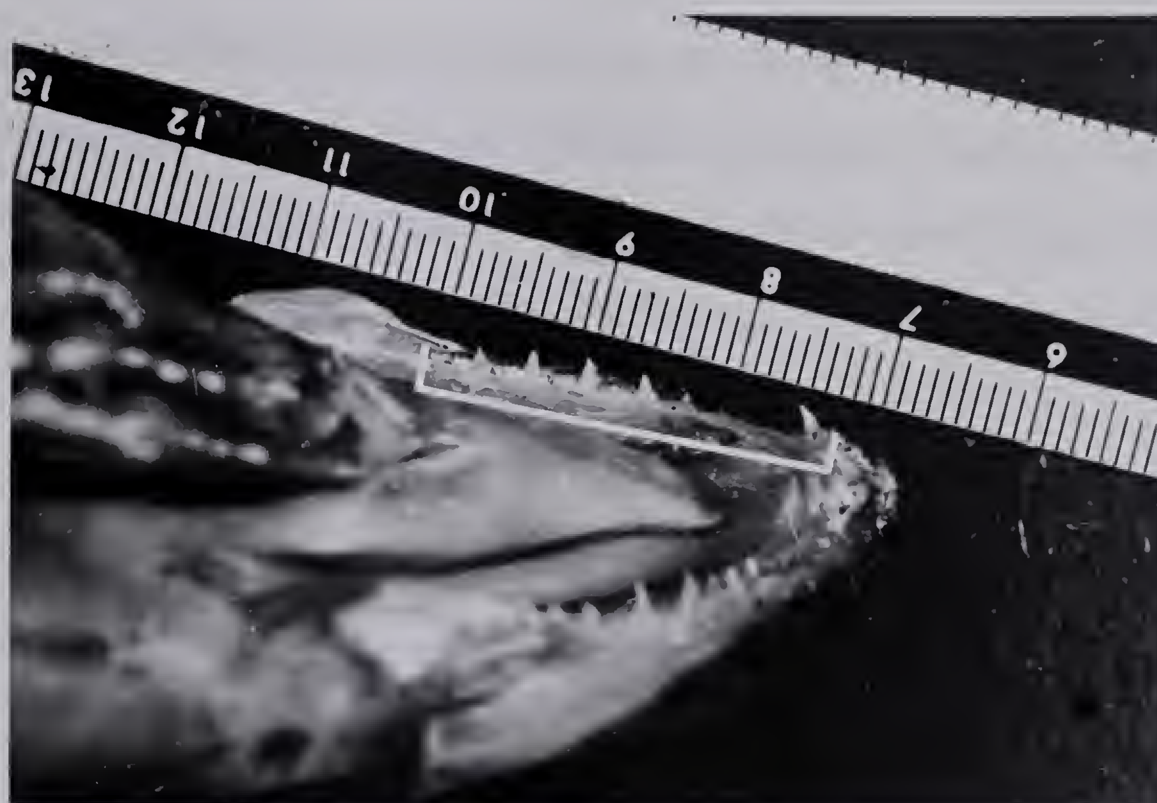
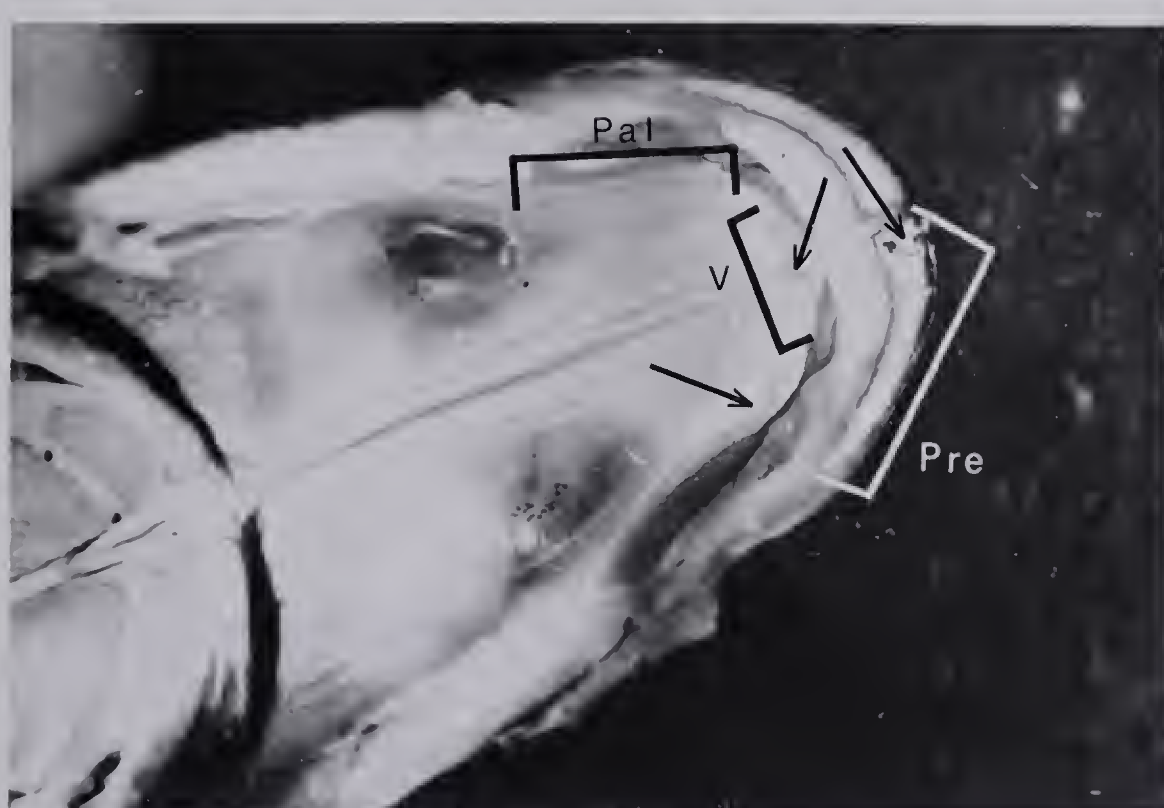
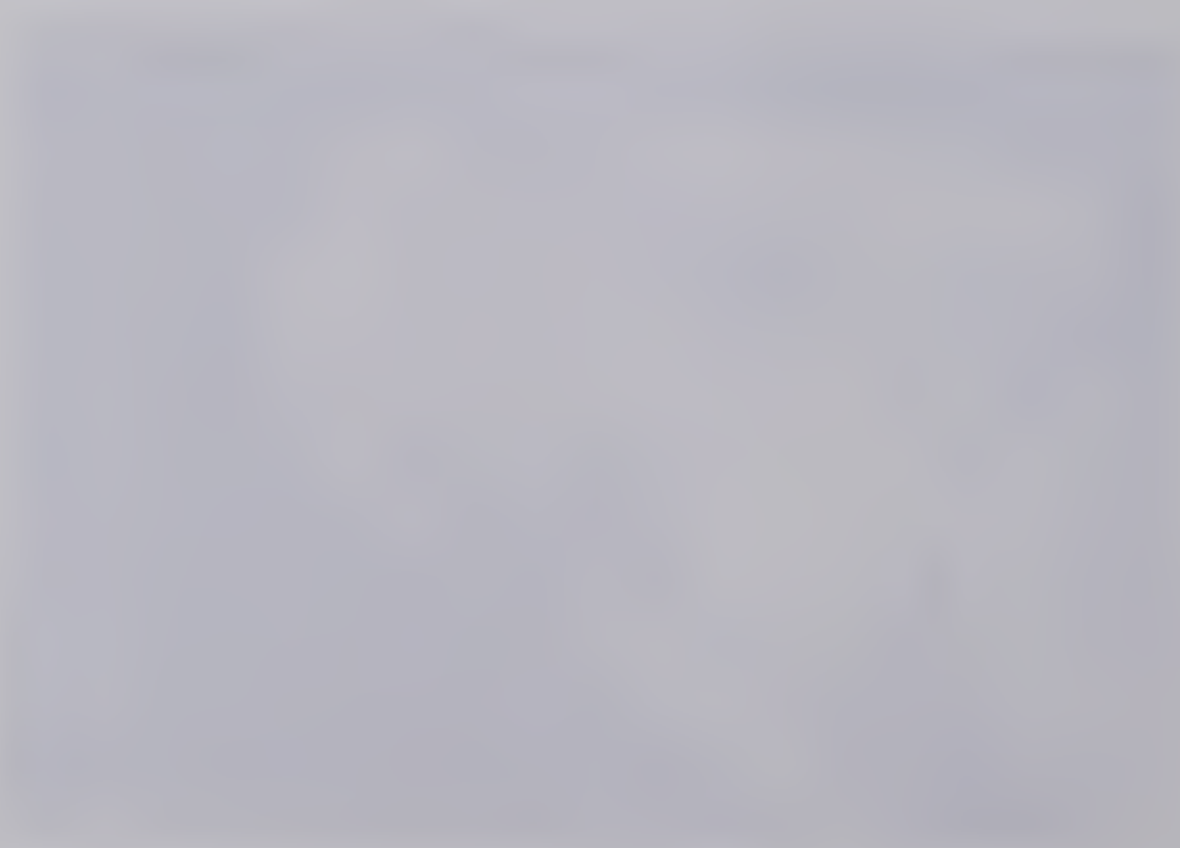
[4]Mauser, West Germany.

Figure 7 The lower jaw of a walleye showing the length of the dentary toothed area. The reference scale in the figure is in centimetres. Magnification: 1.5 actual size.

Figure 8 A ventral view of the roof of a perch mouth. Lengths of the toothed areas of the premaxillary (Pre), palatine (Pal), and vomer (V) bones are shown. The areas where tooth samples were removed for measurement are indicated by arrows. Magnification: 1.9 actual size.


13
12
11
10
9
8
7
6


Pal
V
Pre



of the fork length of each fish thereby giving a standardized measurement. The mean, standard deviation, and standard error of the mean were then calculated for the standardized measurements and body lengths for each species in each seasonal period (Appendix Tables 3 and 4). Significant differences between seasonal periods were determined by Student's unpaired t-test [Steele and Torrie, 1960]. All above calculations were done by computer.[5]

To determine the theoretical size each body part had to attain to represent seasonal isometric growth, an annual mean was calculated for each body part by averaging the standardized body part means from all seasonal periods. This annual standardized body part mean was then multiplied by the fork length of each fish. This gave a theoretical length for each body part of each fish. These theoretical measurements were compared with the actual body lengths by means of Student's t-test[6] to determine which body parts varied significantly from seasonal isometric growth.

In addition, the relative growth constant R [Martin, 1949] was calculated for selected measurements to determine if allometry occurred in the size range studied.

---

[5]Programmed in COBOL with a FORTRAN IV subroutine.

[6]Calculated on an Olivetti Underwood Programma 101.

(d) Seasonal Distribution

The distribution of the size classes studied for each species was based on the number of fish caught per unit effort in each lake area and depth zone during each seasonal period. Different combinations of gill nets were often used in each sample area so a simple totalling of catch of each net set effort (time X net area) would be biased because of lack of uniformity in net areas and mesh sizes in many of the sets. Many of the sets thus had unequal catch efficiencies (fish caught per square metre of net per hour).

Catch efficiency was calculated for each net mesh size. This calculation was based on seven seasonal sets of all the net mesh sizes set together. The 38.1 mm (stretched mesh size) monofilament net was chosen as the standard net. The calculated theoretical areas of the other nets were either increased or decreased to give the same catch efficiency obtained with 19 m^2 of this net.

These new net areas, net set times, and numbers of fish caught in each lake area and depth zone were totalled for each seasonal period. The number of fish caught per square metre of net per hour was calculated for each lake area and depth zone for perch (Tables 3 and 4) and walleye (Tables 5 and 6). This gave an index of fish density in each lake area and depth zone.

Since density is related to population size when living space is considered [Odum, 1959] the number of fish caught per square metre of net per day was multiplied by the number of square kilometers of

lake surface area in each area and depth zone to give an index of total population distribution.

III. RESULTS

A. Environmental Parameters

1. Temperature

Lac Ste. Anne was subjected to great seasonal fluctuation in water temperature ranging from a minimum of 0C in winter to a maximum of 27C in summer. This maximum summer temperature was recorded in shallow shore waters at C19-3 in July 1968. No consistent vertical temperature stratification occurred during the summer although the deeper water and bottom sediments were coolest. After the fall overturn and ice formation, the bottom waters gained heat throughout the winter while the upper layers lost heat thus creating an inversion situation. A summary of seasonal temperatures is given in Appendix Table 5.

2. Dissolved Oxygen

Dissolved oxygen concentrations varied among areas but decreased in all areas throughout the winter. A decrease in oxygen also occurred from top to bottom in each vertical column of water sampled (Appendix Table 6). The sample size of dissolved oxygen determinations is small because an error was introduced into many of the analyses by holding the samples too long in their fixed state [Brown, Skougstad, and Fishman, 1970].

B. Body Growth of the Populations

1. Walleye

The age class distribution of the walleye population did not differ greatly from other reported populations [Eschmeyer, 1950; Niemuth, Churchill, and Wirth, 1966]. The five year age class contained the greatest number of sexually mature individuals. Back-calculation of growth by the method of Carlander and Smith [1944] shows that this age class attained an average length of 42.0 cm (Appendix Table 7). This is considerably larger than most reports for other Canadian waters [MacKay, 1963; Rawson, 1956] although comparable to that of Michigan [Eschmeyer, 1950].

2. Perch

Growth of different age classes of the Lac Ste. Anne perch population (Appendix Table 8) is comparable to other perch populations [Parsons, 1950]. Since no males were longer than 20 cm, the study was based only on females. The five, six, and seven year age classes contributed almost equal numbers of specimens to the study.

Male members of the population were stunted and matured sexually in their second year when they were less than 10 cm long. The biotype theory of Nikolsky [1954] and McCormack [1965] and the eurybiontic polymorphism theory of Nikolsky [1969] suggests that such a male-female size discrepancy in a perch population may be an adaptation to insure species survival.

C. Sample Size, Age and Sex Composition and Fork Length

1. Sample Size

Sample sizes for body measurements and stomach analyses are tabulated in Appendix Tables 3 and 4 for perch and walleye respectively. More perch and walleye were used in the seasonal distribution study (Appendix Tables 9 - 12) than in the study of body measurements and stomach contents.

2. Age and Sex Composition

The ages of the perch and walleye in the size classes studied were between five and eight years. Representatives of each age class were not collected in every seasonal period but the average age did not vary greatly from period to period (Appendix Table 13). Both male and female walleye were studied whereas only female perch were used because males were never longer than 20 cm in fork length. The larger walleyes were usually female but this was the only observed sexually dimorphic character as has also been noted by Eschmeyer [1950] and Rawson [1956]. Student's unpaired t-test ($P < 0.05$) showed no statistical significance between standardized male and female walleye premaxillary tooth lengths ($t = 0.825$) and dentary toothed area lengths ($t = 1.389$) in Period 2. The test was done on this period because of the large sample size it afforded.

3. Fork Length

(a) Preservation Effects

Parker [1963] demonstrated significant maximal shrinkage of salmon fingerlings after 40 days of preservation in formalin. A double series of measurements, one taken before, and the other after two to 12 months of preservation showed no significant difference when compared by Student's paired t-test ($P < 0.05$). The difference in ossification between adult percids and salmon fingerlings would probably account for the discrepancy of results.

(b) Allometric Growth

In comparative morphological studies, most authors avoid the influence of allometry by selecting specimens in one size range [Koehn and Minckley, 1965]. The sizes selected for this study seemed to be free of allometry. This is indicated by a relative growth constant (R) of 1.003 between head and body length and 1.069 between head and dentary length for perch. The same respective measurements yielded constants of 1.015 and 1.098 for walleye. These calculations are based only on Period 2 where the variation in body lengths and sample sizes are large. A relative growth constant of 1.0 indicates total isometric growth [Martin, 1949].

(c) Seasonal

Average body lengths of both perch and walleye differed significantly between seasonal periods (Figures 9 and 10 respectively).

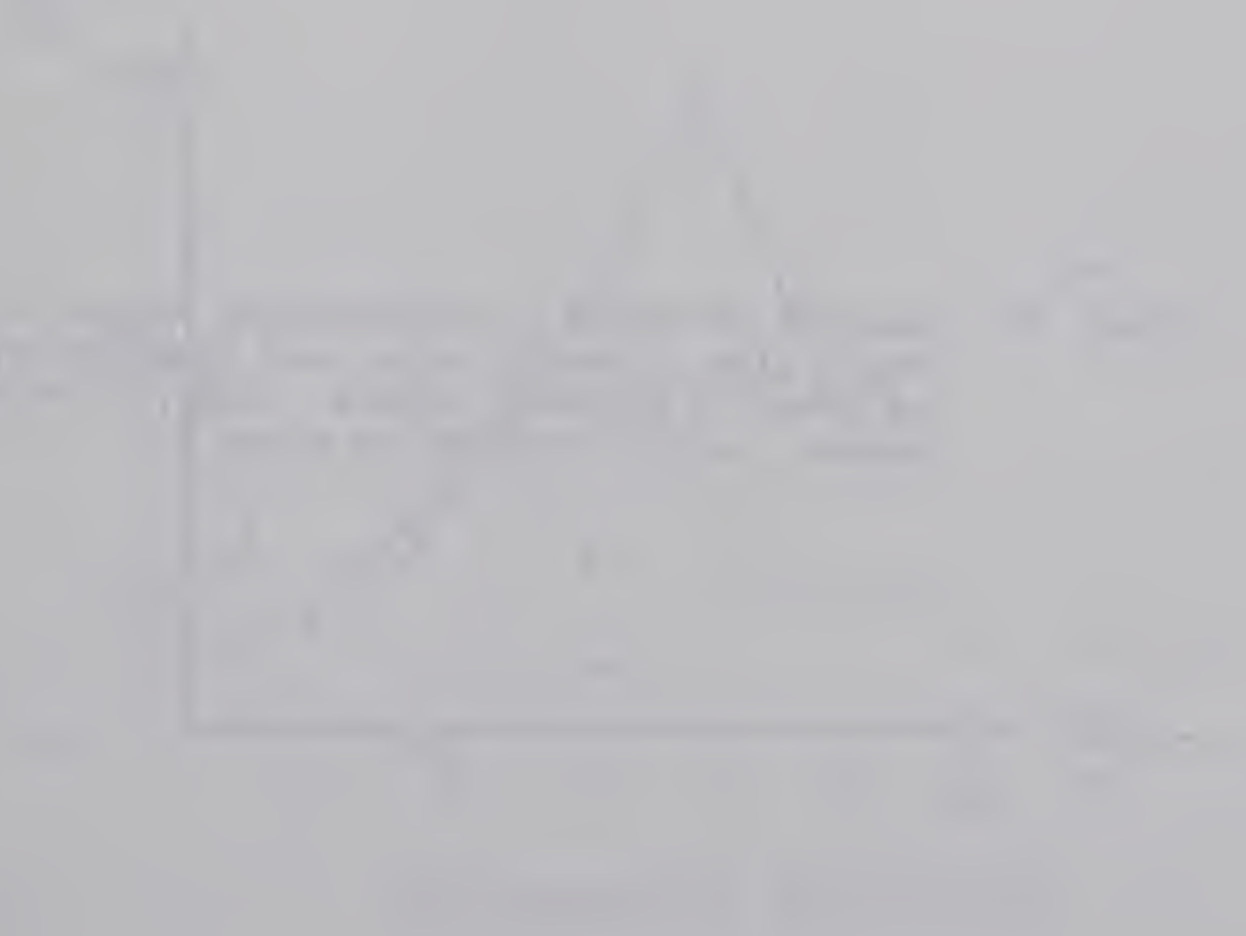


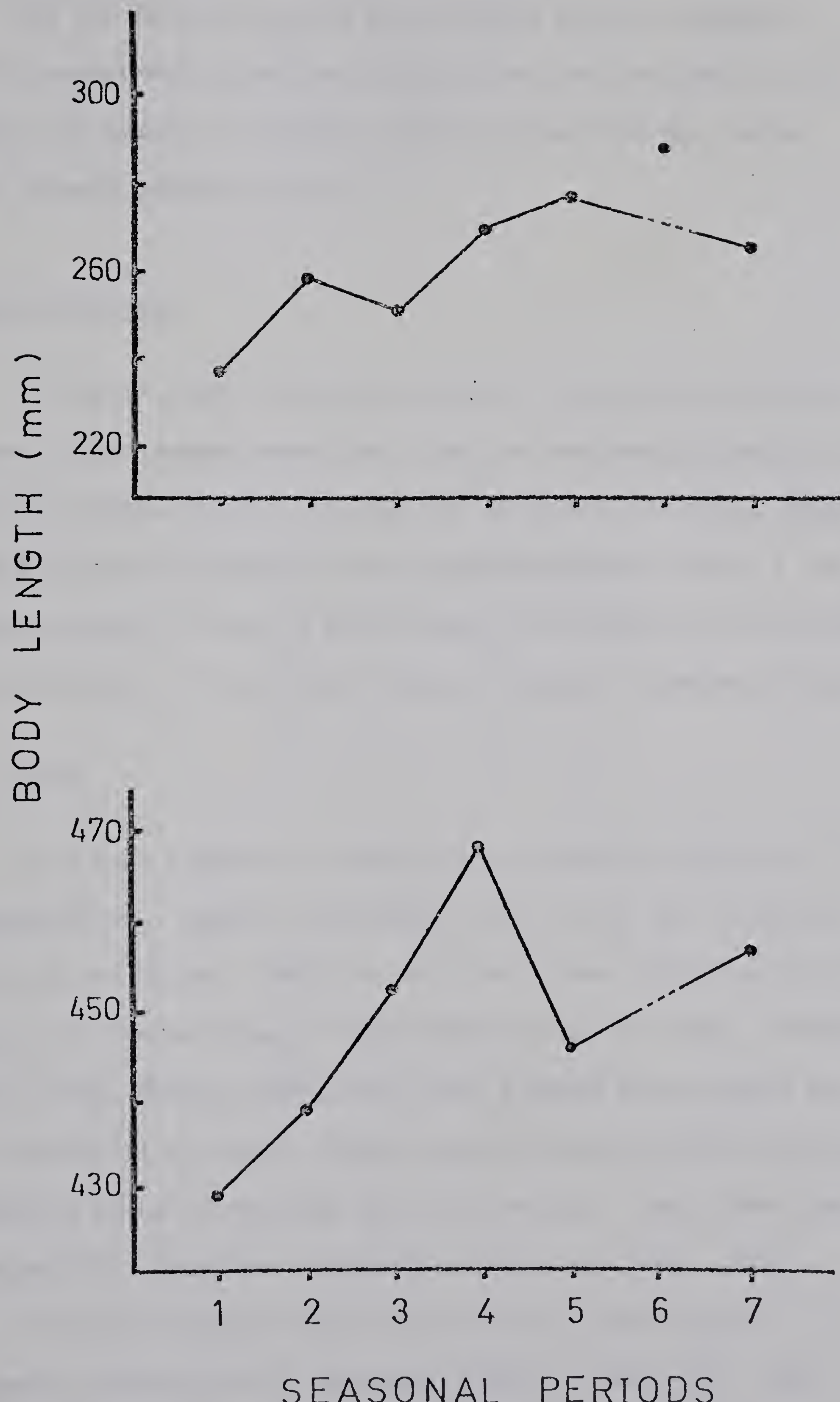
Figure 9 Seasonal variation in average body lengths of perch. Sample size, standard error, and standard deviation are given in Appendix Table 3. Significant differences between seasonal periods are given as;

```
  1       2       3       4       5       7
_____________________           _____
                        _____________________
        _____                           _____
```

Periods underscored at the same level are not significantly different (P < 0.05).

Figure 10 Seasonal variation in average body lengths of walleye. Sample size, standard error, and standard deviation are given in Appendix Table 4. Significant differences between seasonal periods are given as;

```
  1       2       3       4       5       7
_____________                   _____
                _____           _____________
                        _____           _____
```


BODY LENGTH (mm)
300
260
220
470
450
430
1
2
3
4
5
6
7
SEASONAL PERIODS

Average body lengths of both species increased during the summer of 1968. This was probably due to the seasonal growth increment. Since all measurements have been standardized and ontogenetic allometry does not exist, all feeding apparatus measurements can be compared between seasonal periods.

D. Stomach Analyses

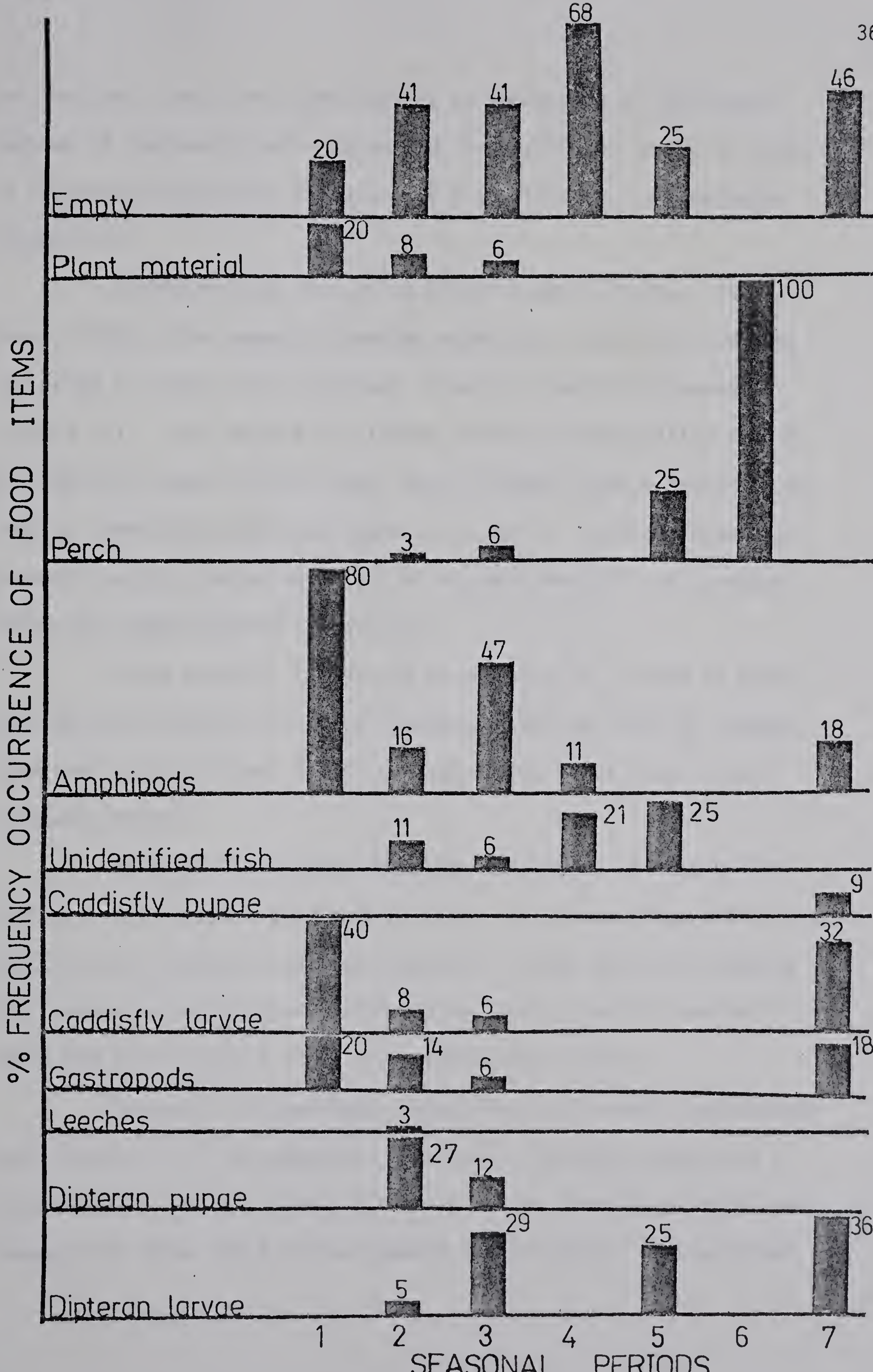
Whenever sample size was adequate, the percent frequency occurrence method demonstrated food type and frequency of empty stomachs. Because this method gives no information on food quantities, weights of all food types are included for each period (Appendix Tables 1 and 2). The average amount of food in each stomach, corrected for differential seasonal digestion, is used as an index of seasonal feeding intensity.

1. Perch

The food studies of adult perch are numerous but few of them are comprehensive. Usually the sample size is very small [Pearse, 1915; Nelson and Hasler, 1942], or only the summer portion of the annual food cycle is studied [Couey, 1935; Keast and Welsh, 1968]. Moffett and Hunt [1943], Hasler [1945], and Keast [1968b] have studied the winter food habits of perch. Pearse and Achtenberg [1920] provide the only complete annual food study for this species. Perch food types from most geographical locations are similar [Keast and Webb, 1966].

Percent frequency occurrence of food types (Figure 11) and other feeding information is presented (Appendix Table 2). Data

Figure 11 Seasonal food types of the perch expressed as percentage frequency occurrence of each food type. The figure is based on values obtained from Appendix Table 2.


% FREQUENCY OCCURRENCE OF FOOD ITEMS
Empty
20
41
41
68
25
46
Plant material
20
8
6
Perch
3
6
25
100
Amphipods
80
16
47
11
18
Unidentified fish
11
6
21
25
Caddisfly pupae
9
Caddisfly larvae
40
8
6
32
Gastropods
20
14
6
18
Leeches
3
Dipteran pupae
27
12
Dipteran larvae
5
29
25
36
1
2
3
4
5
6
7
SEASONAL PERIODS

for Periods 1 and 5 can serve only as an indication of food types because of the small sample sizes and the results of Period 6 cannot be considered meaningful because only a single fish is represented (Figure 11).

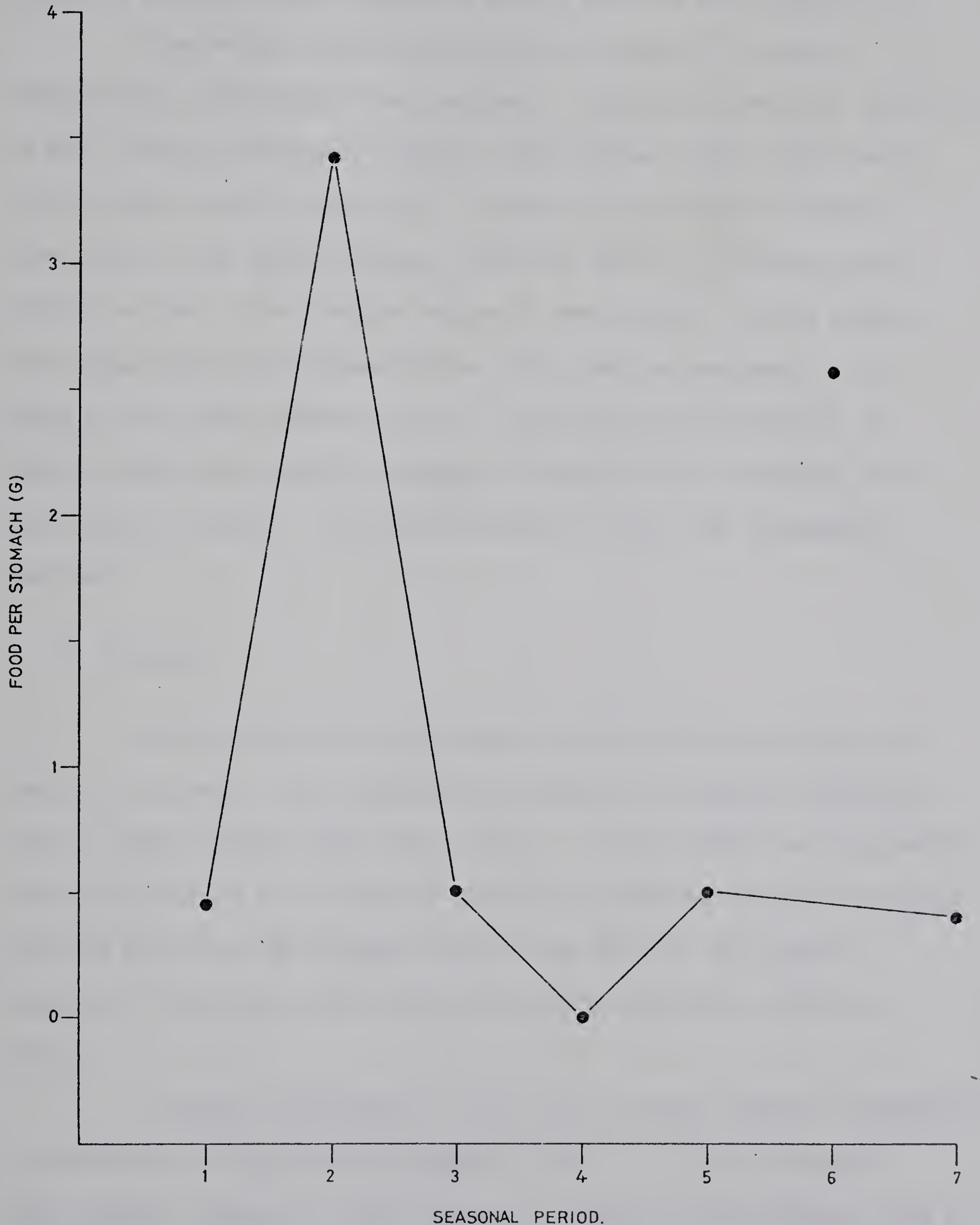
Although perch are active winter feeders [Hasler, 1945; Keast, 1968b], the amount of feeding decreased in the fall and with the onset of winter, the incidence of empty stomachs increased (Figure 11). This pattern is similar to that noted by Allen [1935]. Although not shown in this study, Keast [1968b] noted a cessation of feeding immediately prior to spawning in April. Feeding intensity, based on average corrected weight of stomach contents, was greatest during the summer period (Figure 12).

Plant material (algae and *Potamogeton* sp.) found in perch stomachs was probably incidental because it did not seem to undergo digestion although Munro [1921] suggested that perch could digest vegetable matter.

Although the percent frequency occurrence of fish in the diet was often smaller than that of other food items (Figure 11), the quantity was important (Appendix Table 2). Large perch are usually piscivorous in habit [Couey, 1935; Allen, 1935; Langford and Martin, 1940] and do not depend on an invertebrate food source.

Insects, then amphipods formed the most common invertebrate food (Figure 11). The amphipods were mainly *Hyalella azteca* and a few *Gammarus limnaeus*. Molluscs could not be identified below class because all those found in the stomach lacked shells. Unlike other

Figure 12 Average weight of food per perch stomach corrected for digestion in all seasonal periods with an average temperature greater than 4C. Figure based on uncorrected values taken from Appendix Tables 2 and 3.


FOOD PER STOMACH (G)
0
1
2
3
4
1
2
3
4
5
6
7
SEASONAL PERIOD.

perch populations [McCormack, 1965; Galbraith, 1967], copepod and cladocera planktors were completely absent from the diet (Figure 11).

Food insects consisted of aquatic stages of Tricoptera (Phyganeidae) and Diptera (Tendipedidae). Caddisfly larvae are restricted to the littoral environment [Pennak, 1953] and were only exploited in the ice free season (Figure 11). The pupal stage exists for only a short time in the spring [Pennak, 1953] and thus is of limited availability as food. Since midges emerge in great numbers in the summer, their pupal stages were common in the diet prior to emergence. The midge larval stage is common in all lake areas characterized by an organic benthos and usually increase in density with increasing lake depth [Hasler, 1945]. They are available as fish food throughout the year.

2. Walleye

Walleye food habits have been studied less intensively than those of the perch. The comprehensive studies of Eschmeyer [1950] and Rawson [1956] consider only summer diets. Priegel [1963] has documented winter food habits but no one has studied the complete annual food cycle. The food habits of the European form of the walleye, the Zander, *Lucioperca lucioperca*, have been studied more intensively [Robins, 1970].

Frequency occurrence of food items and other feeding information are presented in Figure 13 and Appendix Table 1. The incidence of empty walleye stomachs is high (Figure 13) except during Periods 2 and 3

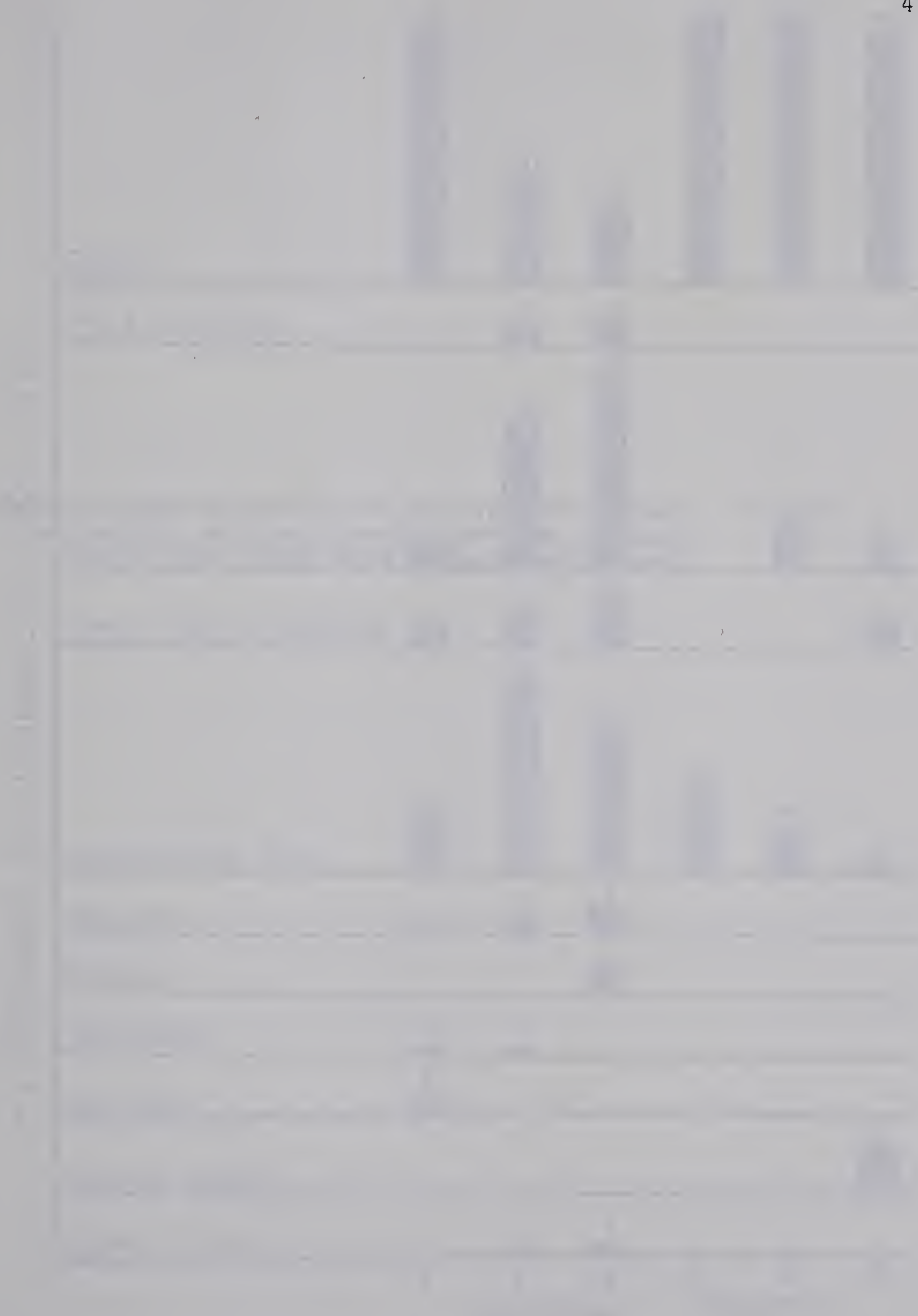
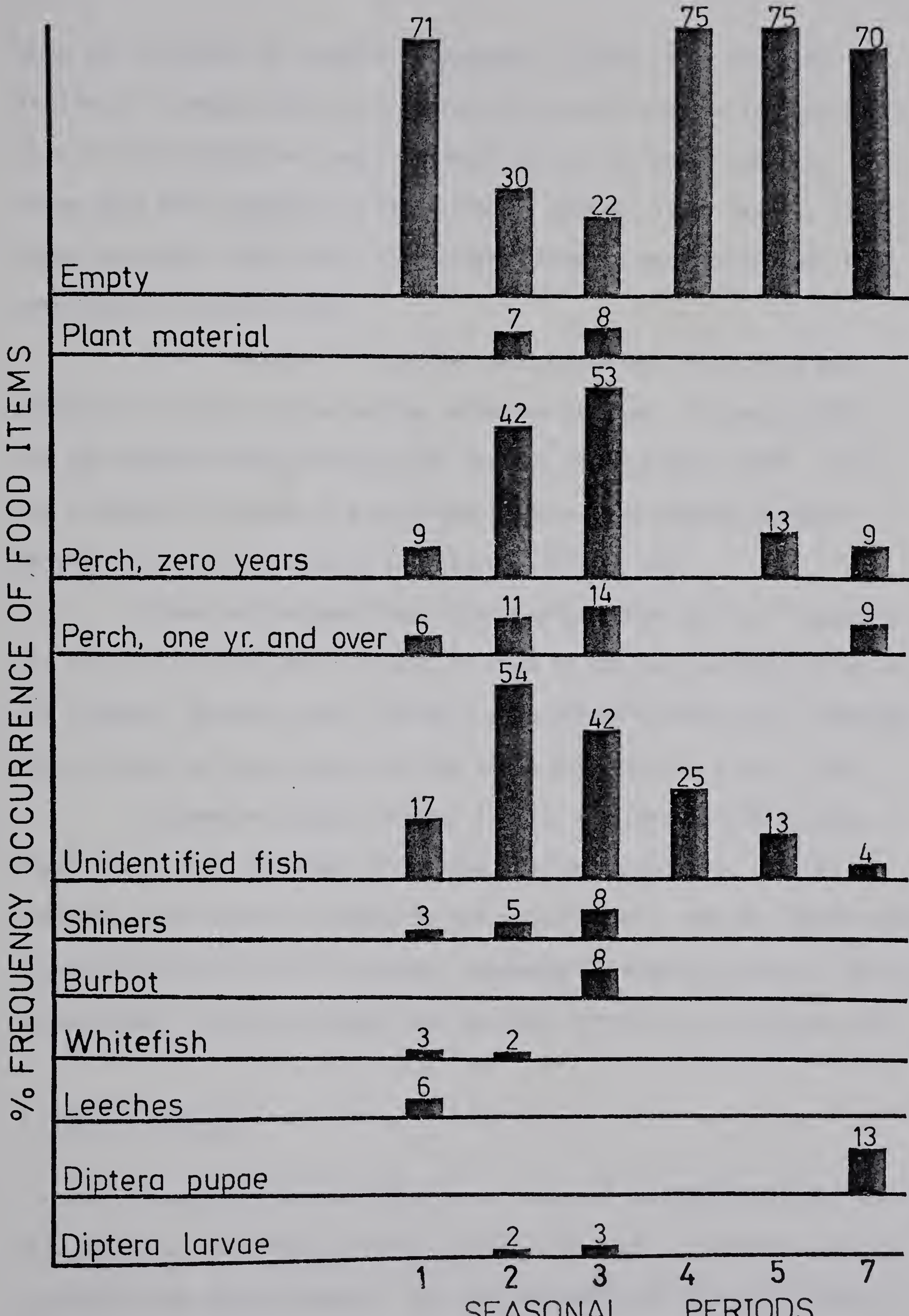


Figure 13 Seasonal food types of the walleye expressed as percent frequency occurrence of each food type. Values are obtained from Appendix Table 1.


% FREQUENCY OCCURRENCE OF FOOD ITEMS
Empty
71
30
22
75
75
70
Plant material
7
8
Perch, zero years
9
42
53
13
9
Perch, one yr. and over
6
11
14
9
Unidentified fish
17
54
42
25
13
4
Shiners
3
5
8
Burbot
8
Whitefish
3
2
Leeches
6
Diptera pupae
13
Diptera larvae
2
3
1
2
3
4
5
7
SEASONAL PERIODS

when the intensity of feeding is greatest (Figure 14). Thus the incidence of empty stomachs is inversely proportional to feeding intensity. The incidence of empty stomachs during Periods 2 and 3 is lower than that reported in other studies [Couey, 1935; Rawson, 1956; Glenn and Ward, 1968] while the winter incidence was higher than that reported by Priegel [1963].

Plant material in the diet was mainly *Nostoc* sp. and was probably mistaken as prey during intensive feeding. Priegel [1963] did not consider plant material as part of the walleye's diet. With the exception of algae, the occasional leech, and aquatic dipteran stages, walleye were totally piscivorous (Figure 13).

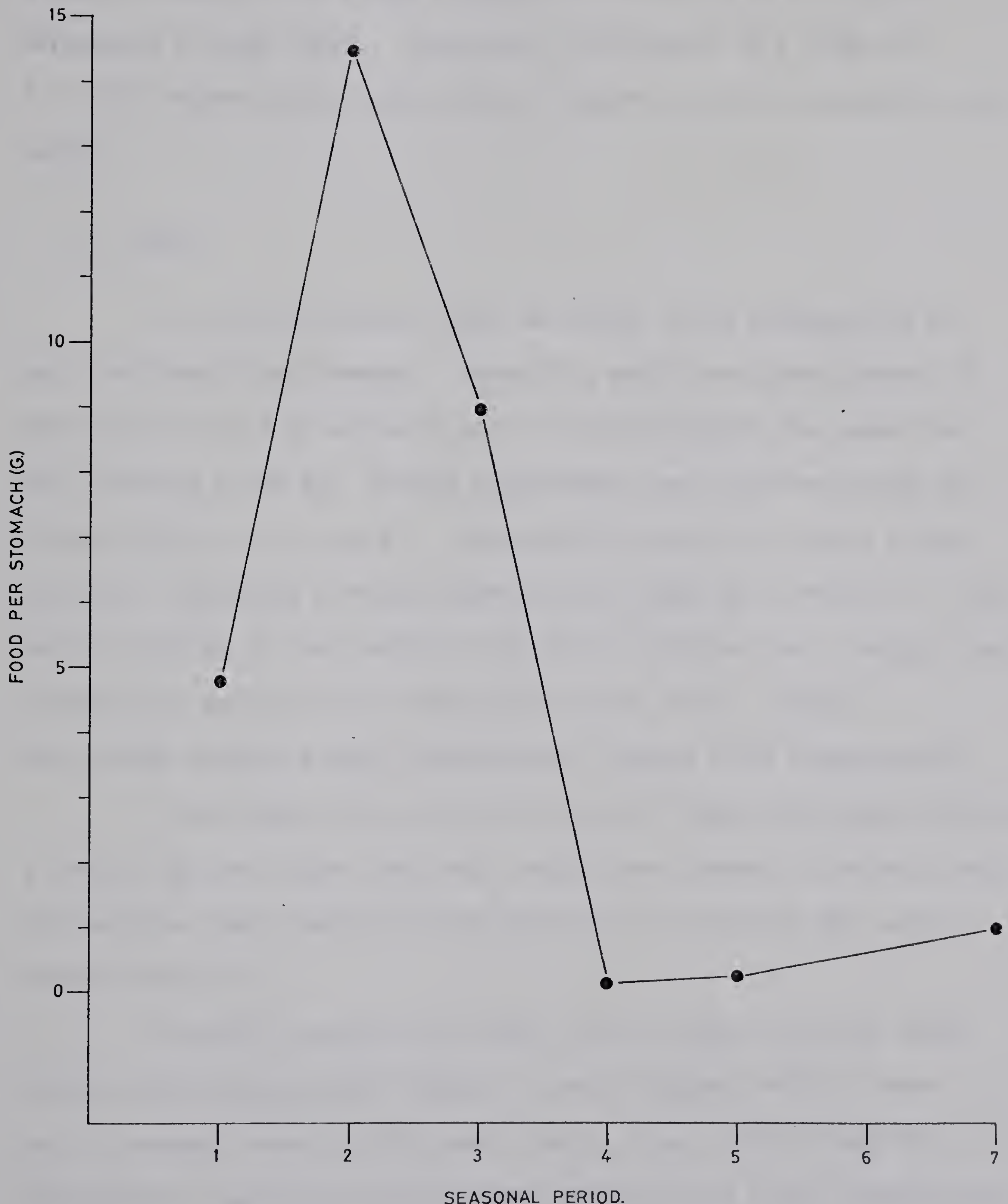
Perch and unidentified fish remains occurred most frequently and contributed the greatest mass of food to the walleye population in all seasonal periods except Period 1 when whitefish were most important. This was due to the presence of one large whitefish as a prey item.

Eschmeyer [1950], Priegel [1963], and Parsons [1971] have shown that perch, if common in a lake containing walleye, usually contribute the greatest amount to the walleye diet. Rawson [1956] noted a scarcity of perch in Lac La Ronge, consequently another species, the ciscoe (*Leucichthys* sp.), contributed the greatest amount to the walleye diet.

E. Mouth Anatomy

Anatomical measurements were compared seasonally by statistically denoting differences between seasonal periods and between seasonal isometric and actual growth. This was accomplished by use of Student's unpaired and paired t-tests respectively.

Figure 14 Average weight of food per walleye stomach corrected for digestion in all seasonal periods with an average temperature greater than 4C. Figure based on uncorrected values taken from Appendix Tables 1 and 4.


15
10
5
0
FOOD PER STOMACH (G.)
1
2
3
4
5
6
7
SEASONAL PERIOD.

In Figures 15-40 standardized measurements (mean values as a percentage of mean body length) are shown for both species. Seasonal isometric growth of each body component is indicated as a constant percentage of body length. Significant differences ($P < 0.05$ and $P < 0.10$) between actual and seasonal isometric growth is shown for each period.

1. Perch

A distinct seasonal trend was found in the average size of most perch mouth measurements. Generally, mouth parts were largest in the spring (Period 1) and decreased in size throughout the summer and fall (Periods 2 and 3). Minimal measurements were observed during and winter (Periods 4, 5, and 6). Measurements during the second spring (Period 7) indicated a return towards values observed in Period 1. This pattern applies to the lengths of the dentary toothed area, dentary teeth, premaxillary toothed area, premaxillary teeth, vomer toothed area, vomer teeth and mouth indentations (Figures 15-21 respectively).

Head (Figure 22) and palatine tooth (Figure 23) lengths followed a similar pattern except that head lengths were largest in Period 2 and the palatine tooth lengths did not decrease in size until the early winter (Period 4).

Palatine toothed area lengths, mouth widths, and gill raker lengths exhibited seasonal isometric growth (Figures 24-26). There was no seasonal trend in gill raker counts (Figure 27) although the statistically smallest counts occurred during Period 2 when feeding was most intensive (Figure 12).

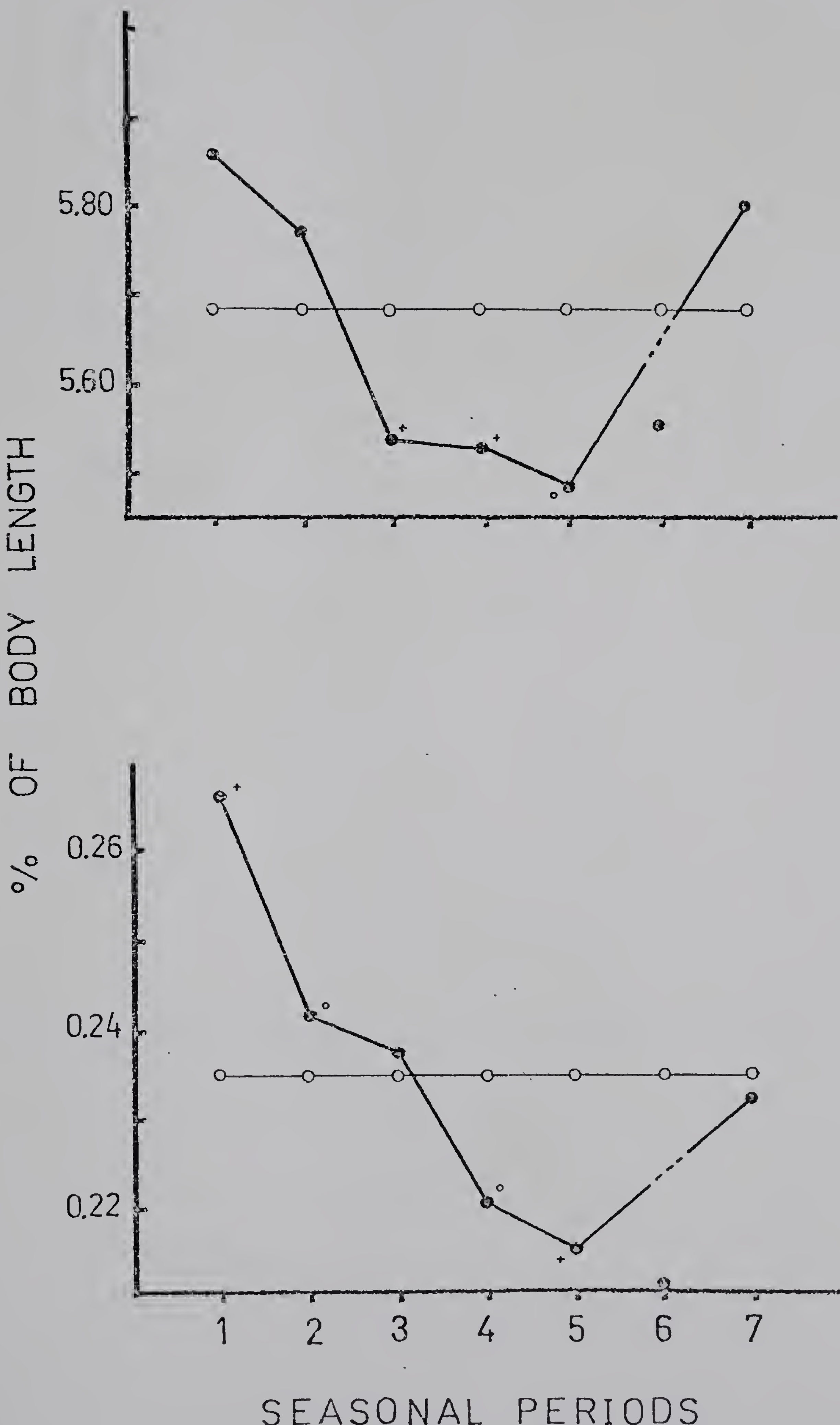
Figure 15 Seasonal variation in lengths of dentary toothed areas of perch expressed as a percentage of body length. Closed circles (●) represent actual mean values and large open circles (○) represent theoretical values. Significant differences between actual and theoretical values are symbolized by small open circles (∘) and crosses (+) for the five and 10 percent levels of probability respectively. Significant differences between seasonal periods are given as;

1 2 3 4 5 7

Periods underscored at the same level are not significantly different ($P < 0.05$). Sample size, standard error of the mean, and standard deviation are given in Appendix Table 3.

Figure 16 Seasonal variation in lengths of perch dentary teeth. All values are represented as in Figure 15.

1 2 3 4 5 7


5.80
5.60
% OF BODY LENGTH
0.26
0.24
0.22
1 2 3 4 5 6 7
SEASONAL PERIODS

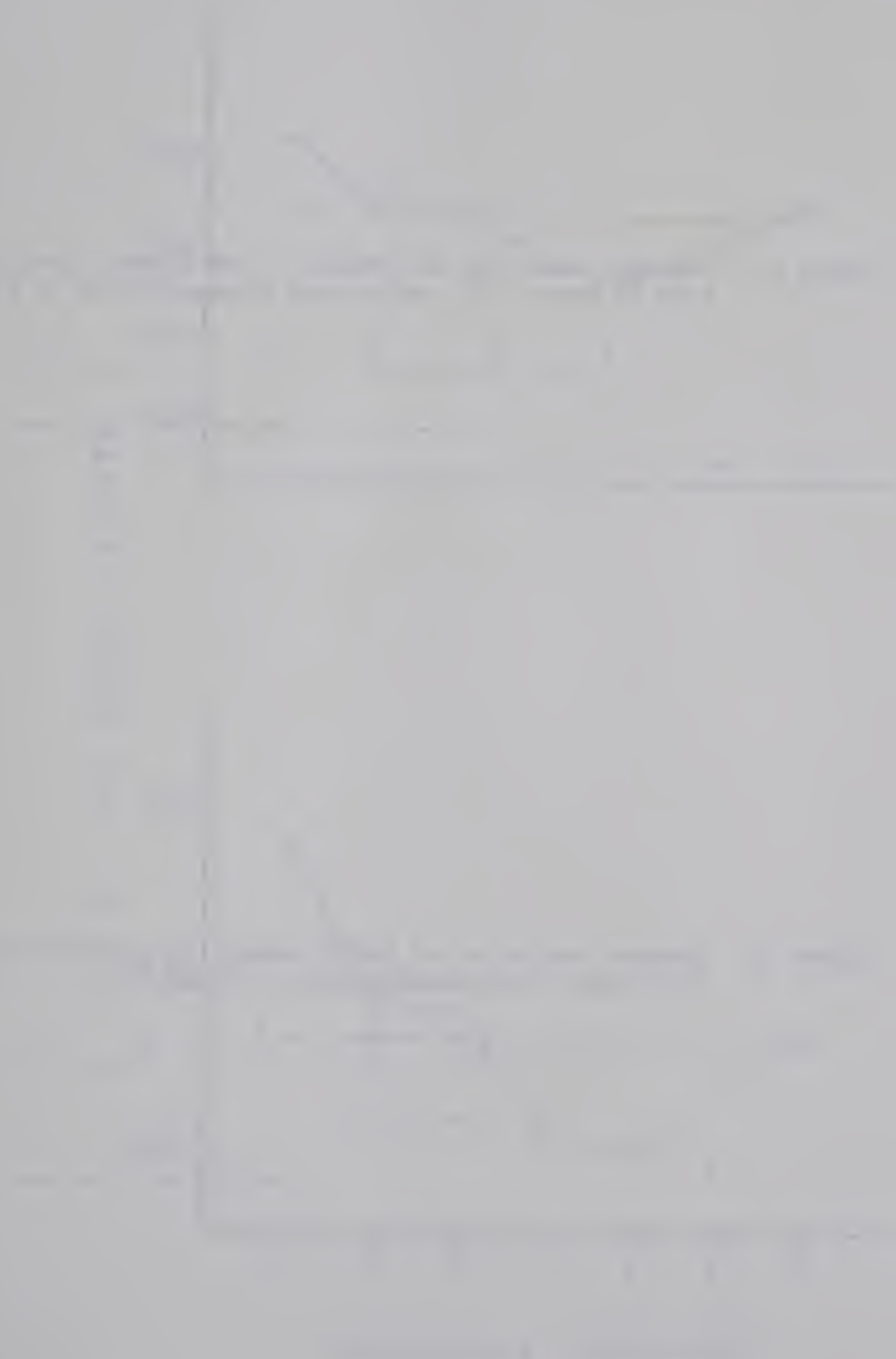
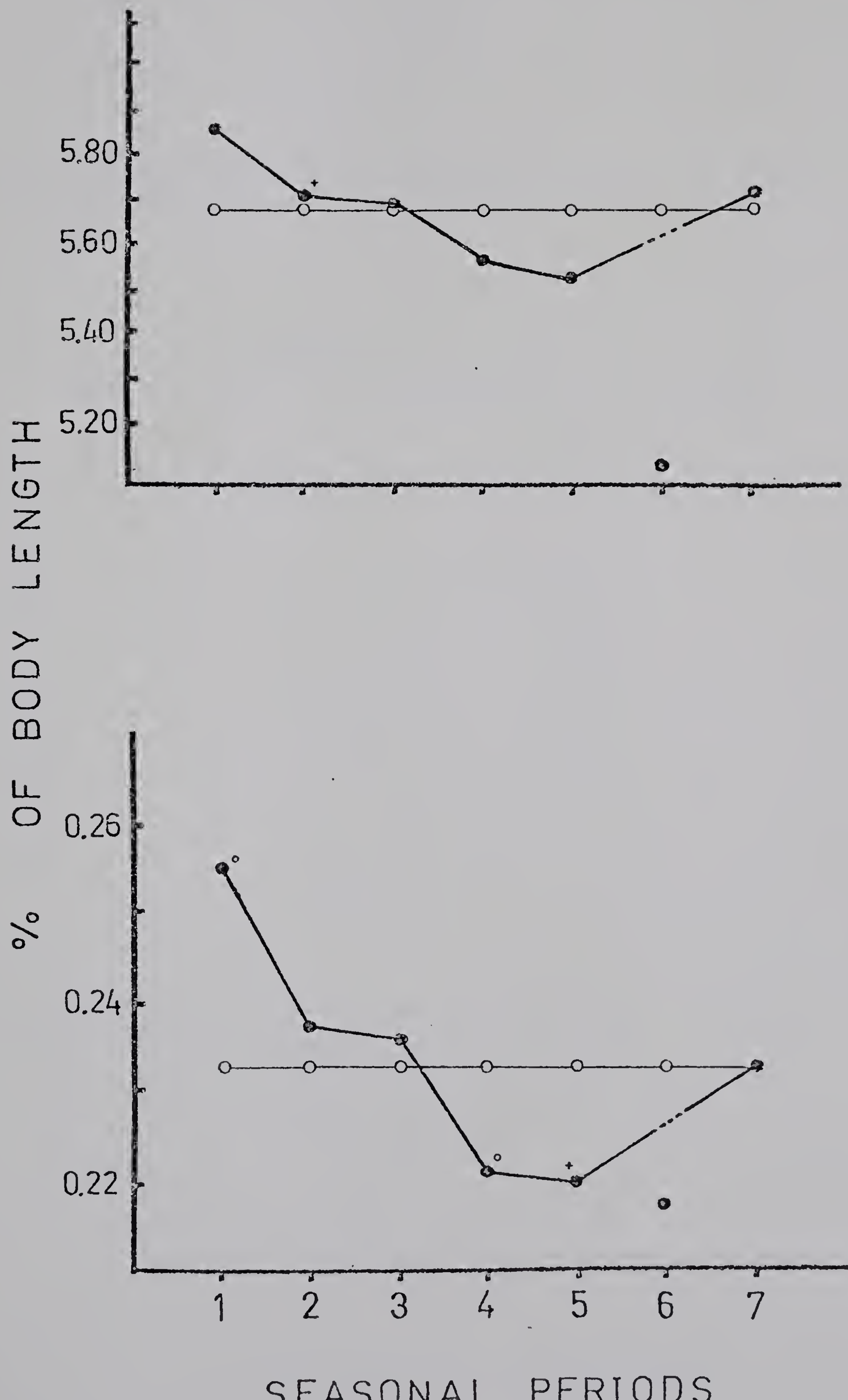


Figure 17 Seasonal variation in lengths of the premaxillary toothed area of perch. All values are represented as in Figure 15.

1 2 3 4 5 7

Figure 18 Seasonal variation of perch premaxillary tooth lengths. All values are represented as in Figure 15.

1 2 3 4 5 7



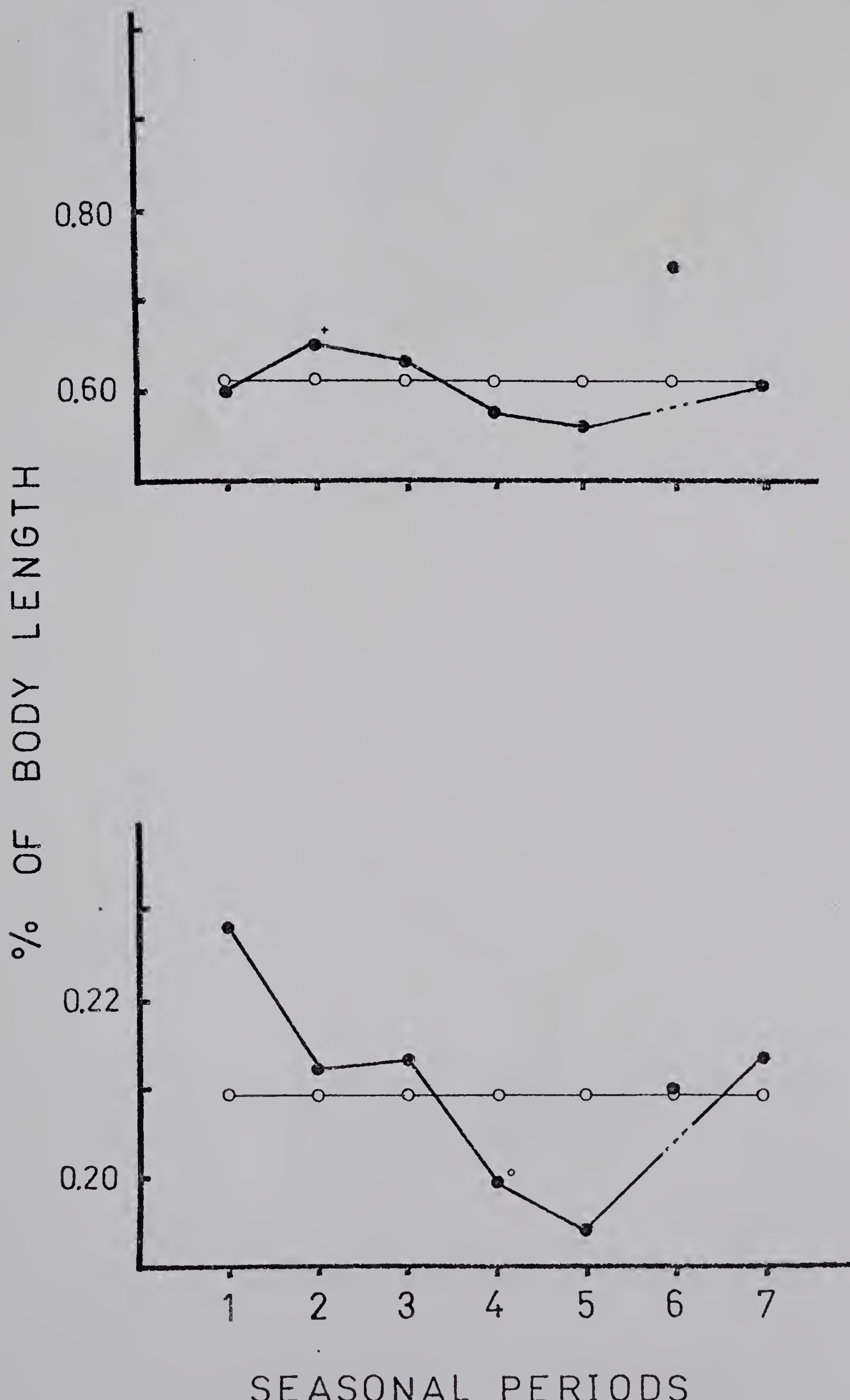
5.80
5.60
5.40
5.20
0.26
0.24
0.22
% OF BODY LENGTH
1
2
3
4
5
6
7
SEASONAL PERIODS

Figure 19 Seasonal variation in the vomer toothed area lengths of perch. All values are represented as in Figure 15.

1 2 3 4 5 7

Figure 20 Seasonal variation in the lengths of perch vomer teeth. All values are represented as in Figure 15.

1 2 3 4 5 7


0.80
0.60
% OF BODY LENGTH
0.22
0.20
1
2
3
4
5
6
7
SEASONAL PERIODS

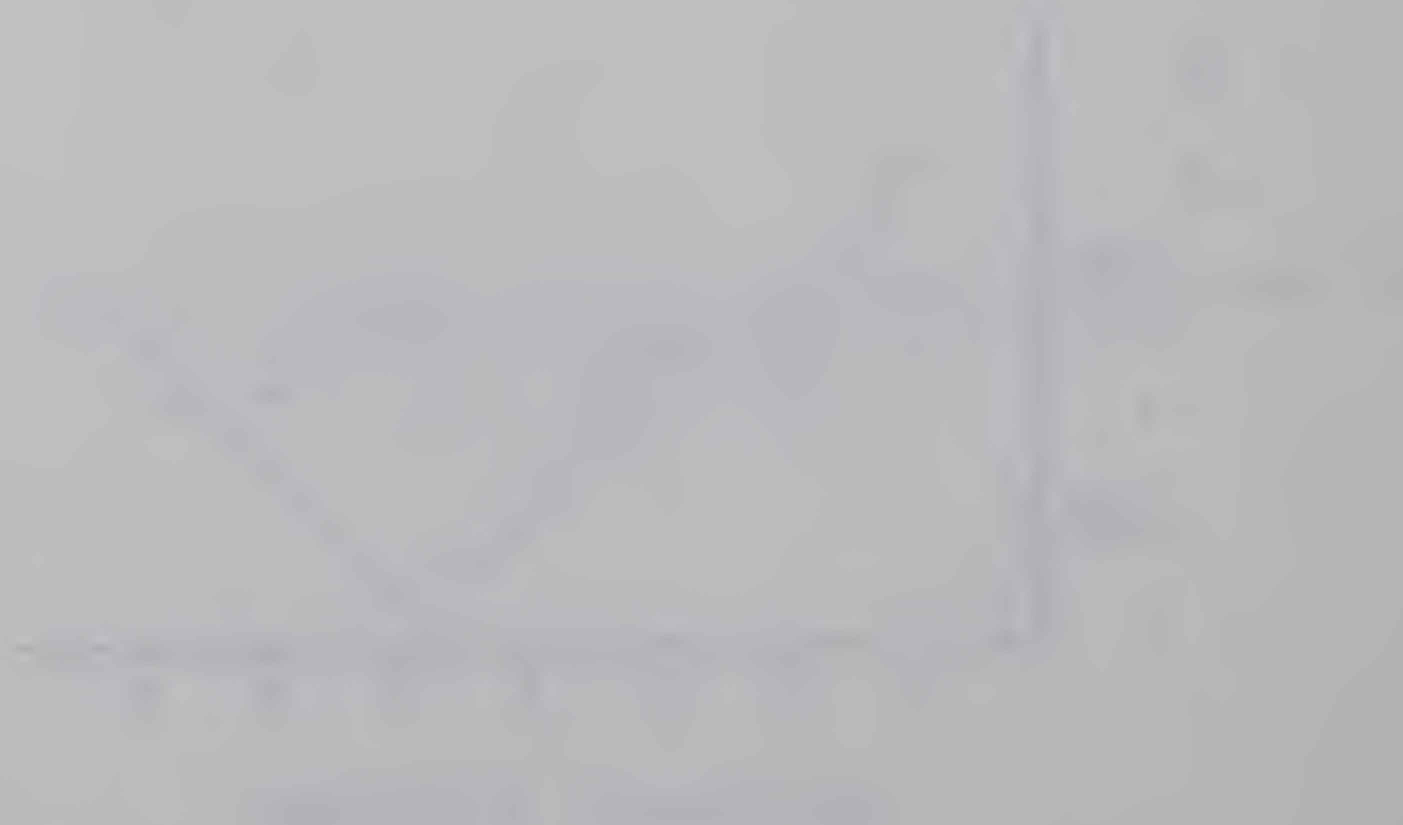
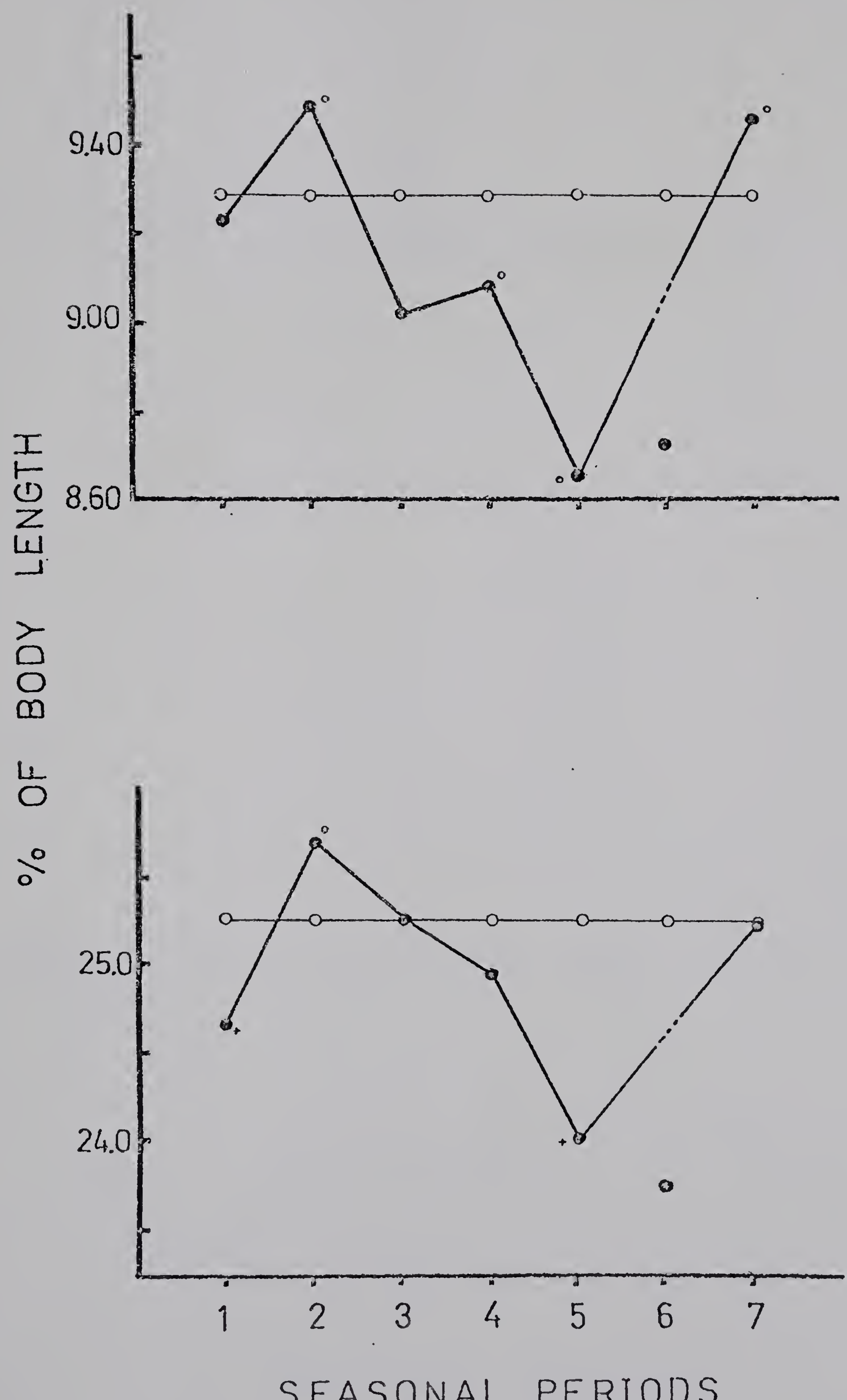


Figure 21 Seasonal variation in length of mouth indentation of perch. All values are represented as in Figure 15.

1 2 3 4 5 7

Figure 22 Seasonal variation in head length of perch. All values are represented as in Figure 15.

1 2 3 4 5 7



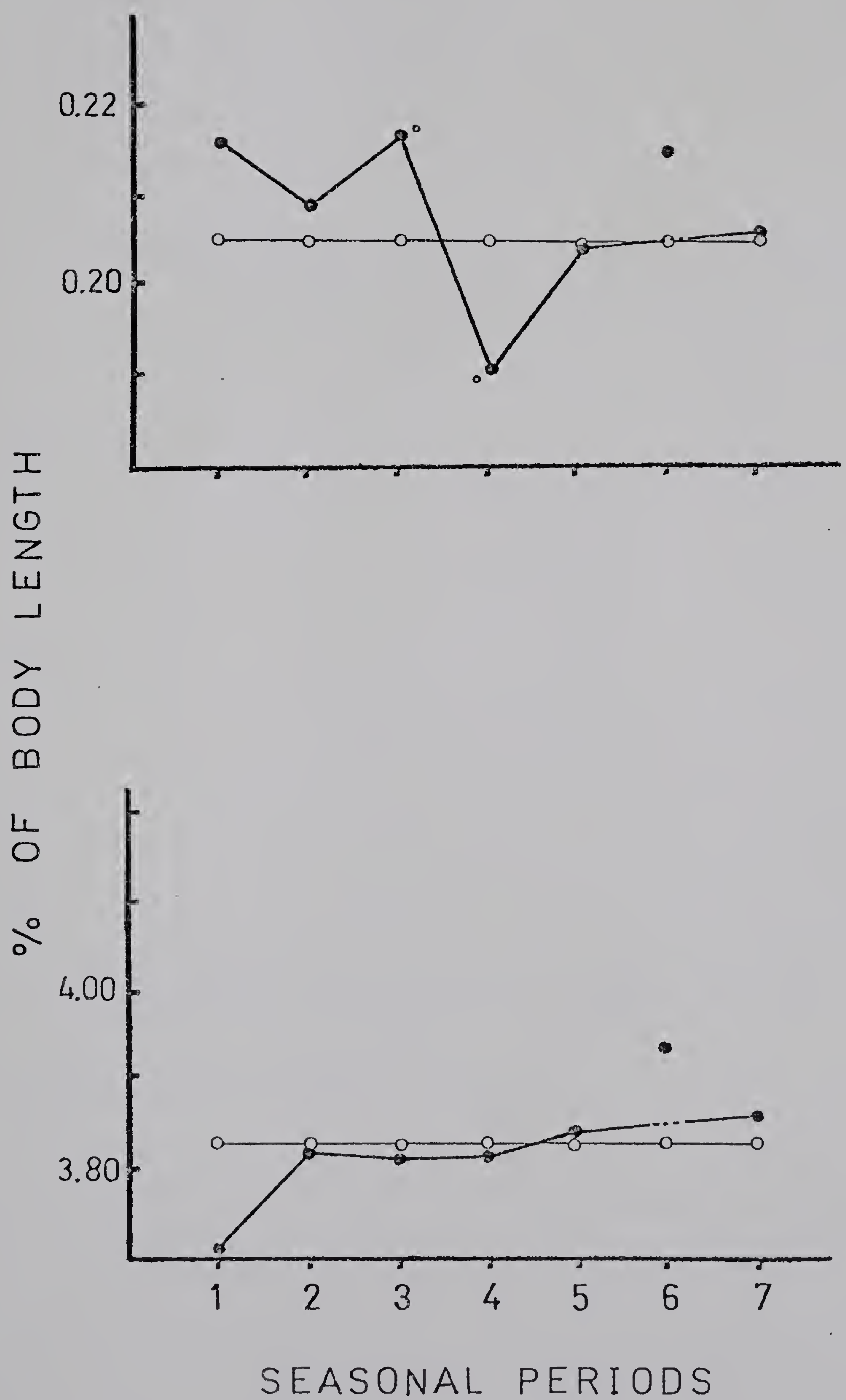
9.40
9.00
8.60
% OF BODY LENGTH
25.0
24.0
1
2
3
4
5
6
7
SEASONAL PERIODS

Figure 23 Seasonal variation in perch palatine tooth lengths. All values are represented as in Figure 15.

1 2 3 4 5 7

Figure 24 Seasonal variation in the lengths of the palatine toothed areas of perch. All values are represented as in Figure 15.

1 2 3 4 5 7


0.22
0.20
% OF BODY LENGTH
4.00
3.80
1
2
3
4
5
6
7
SEASONAL PERIODS

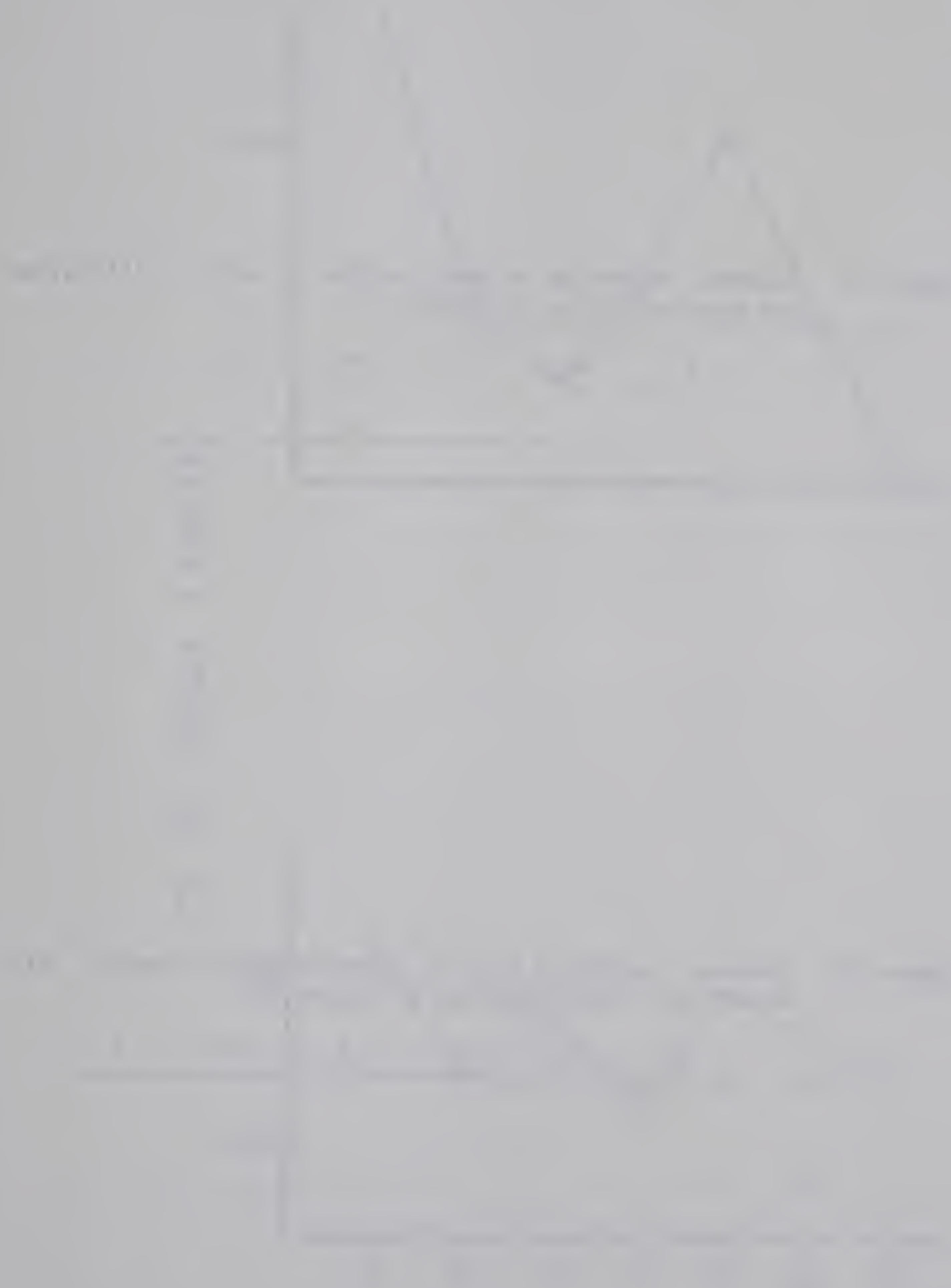
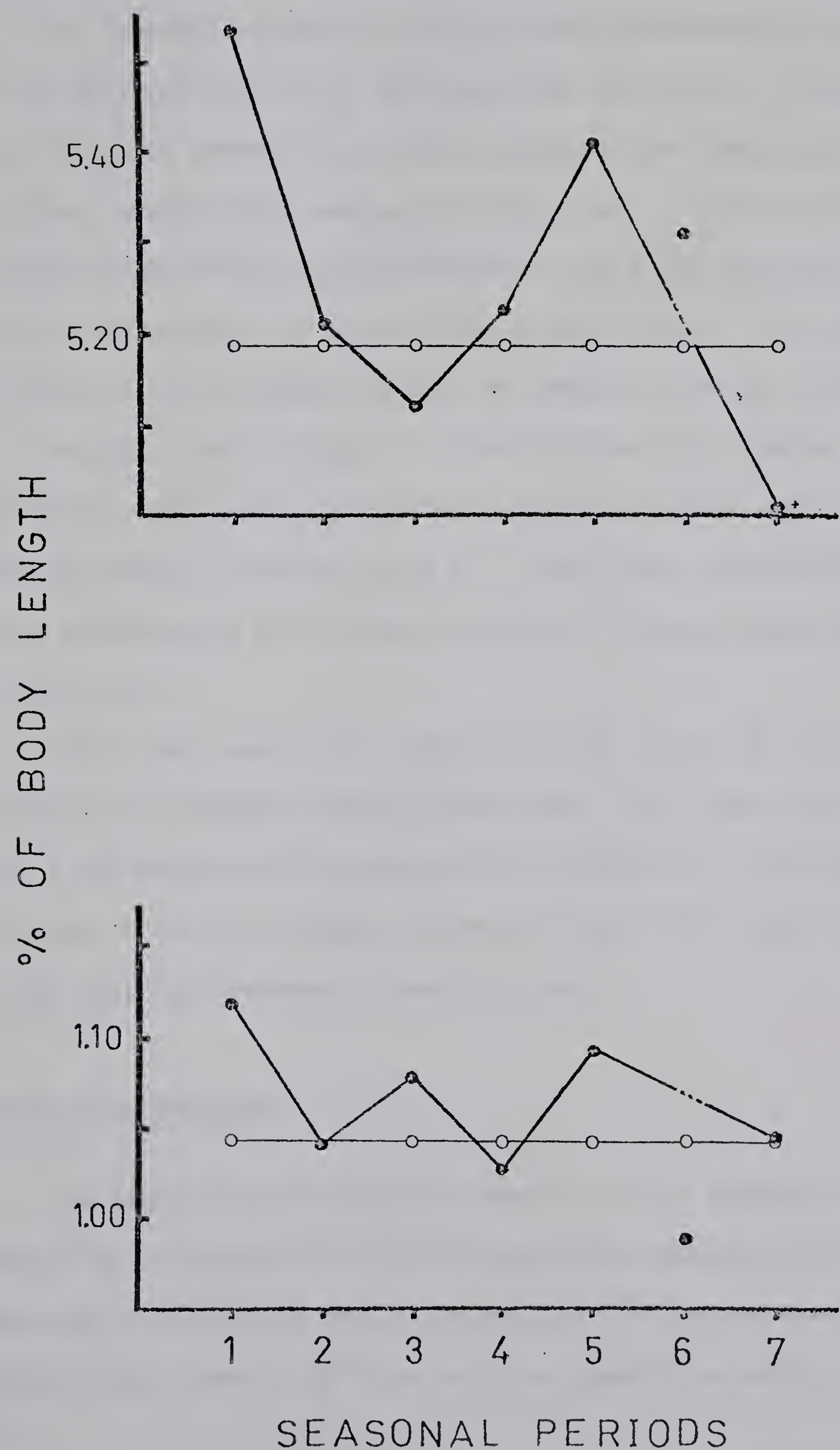


Figure 25 Seasonal variation in mouth widths of perch. All values are represented as in Figure 15.

1 2 3 4 5 7

Figure 26 Seasonal variation in gill raker lengths of perch. All values are represented as in Figure 15.

1 2 3 4 5 7


5.40
5.20
% OF BODY LENGTH
1.10
1.00
1 2 3 4 5 6 7
SEASONAL PERIODS

2. Walleye

The seasonal pattern in walleye mouth measurements did not apply to as many mouth parts as that described for perch. Average lengths of dentary, premaxillary, vomer, and palatine teeth, palatine toothed areas, mouth widths and mouth indentations (Figures 28-34 respectively) were greatest during Periods 2 and 3 and decreased throughout the fall and winter to minimal sizes in the spring. This pattern closely parallels the seasonal changes in feeding intensity (Figure 14).

Dentary, premaxillary, and vomer toothed area lengths (Figures 35-37 respectively) are characterized by maximum size in early and midwinter seasons (Periods 4 and 5). These measurements exhibit an inverse relationship to the tooth lengths of the same bone structures for Periods 2 to 5.

Gill raker counts and lengths (Figures 38 and 39) do not exhibit any of the seasonal trends noted above. Gill rakers were longest in Period 1 and decreased to minimum size in Period 3. This trend is thus inversely related to feeding intensity (Figure 14). Head lengths (Figure 40) exhibited seasonal isometric growth.

F. Distribution Analyses

The seasonal distribution of the fish sizes studied is shown by a comparison of indices of relative population numbers (fish caught per square metre of net per net set hour multiplied by the area of the study area or depth zone X 10^5) and relative population density (fish

Figure 27 Seasonal variation in perch gill raker counts. All values are represented as in Figure 15.

1 2 3 4 5 7

Figure 28 Seasonal variation in lengths of walleye dentary teeth. Sample size, standard error of the mean, and standard deviation are given in Appendix Table 4. All other values are represented as in Figure 15.

1 2 3 4 5 7

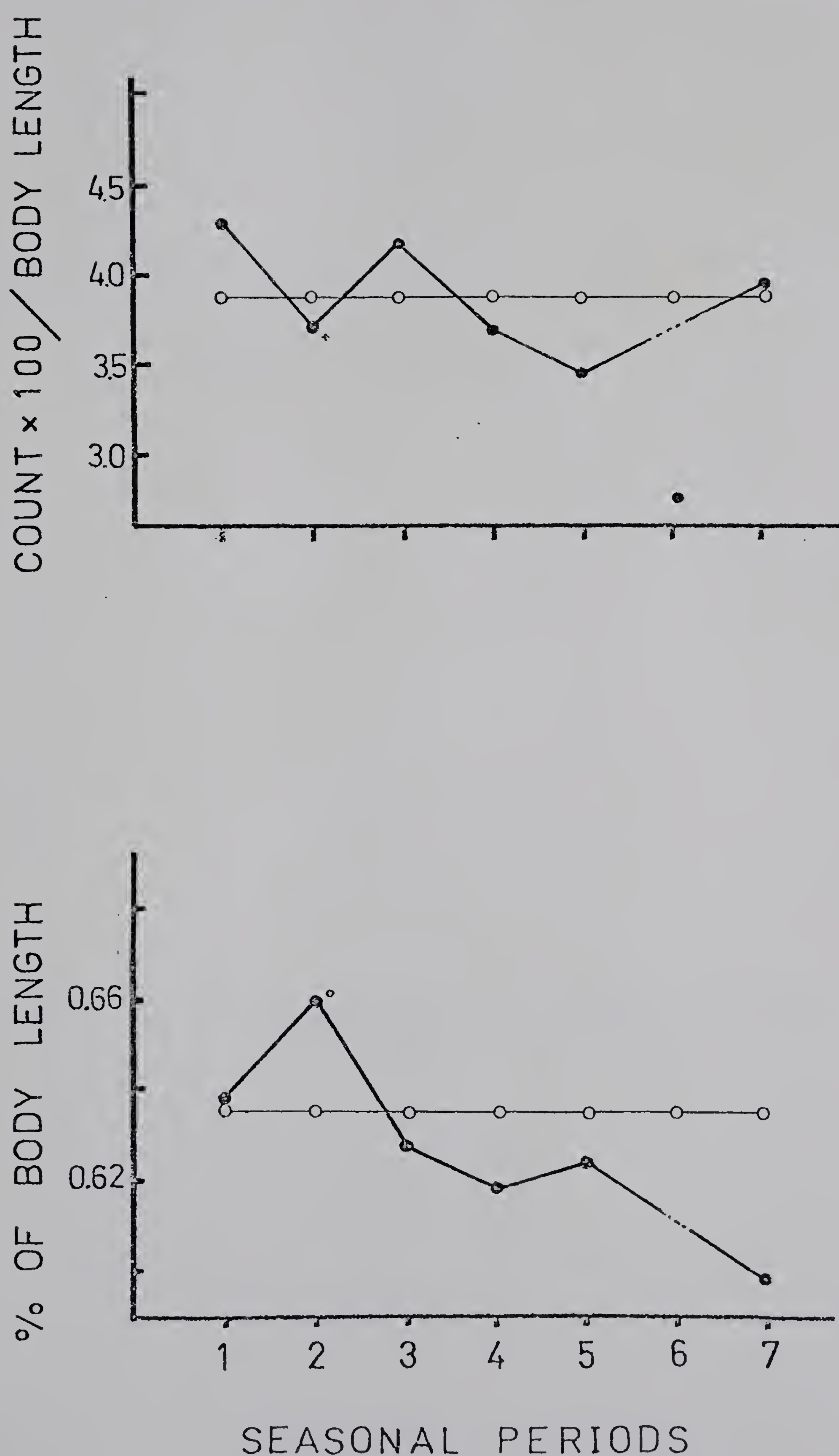
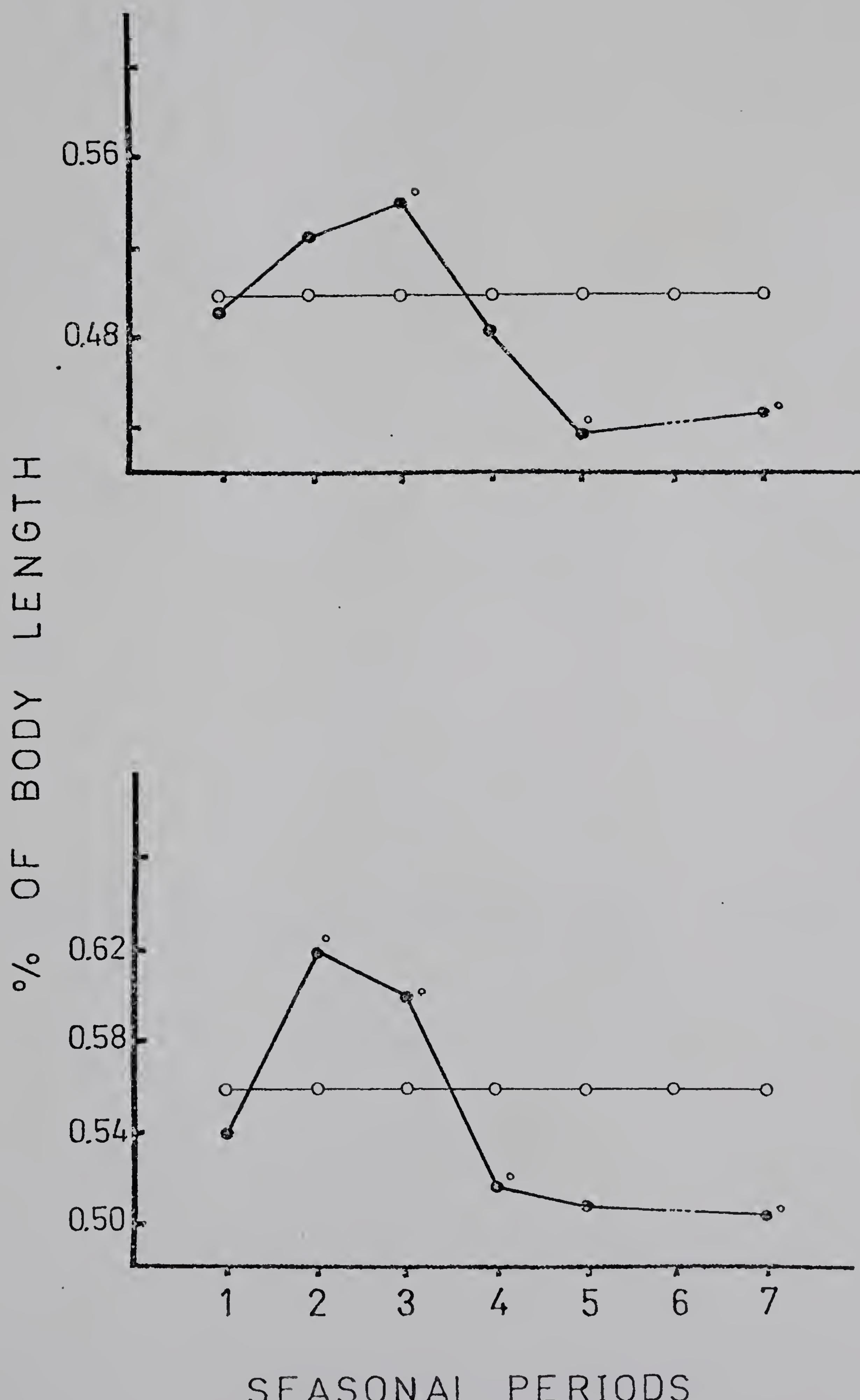

COUNT × 100 / BODY LENGTH
4.5
4.0
3.5
3.0
% OF BODY LENGTH
0.66
0.62
1
2
3
4
5
6
7
SEASONAL PERIODS

Figure 29 Seasonal variation in lengths of walleye premaxillary teeth. All values are represented as in Figure 28.

1 2 3 4 5 7

Figure 30 Seasonal variation in lengths of walleye vomer teeth. All values are represented as in Figure 28.

1 2 3 4 5 7


0.56
0.48
% OF BODY LENGTH
0.62
0.58
0.54
0.50
1
2
3
4
5
6
7
SEASONAL PERIODS

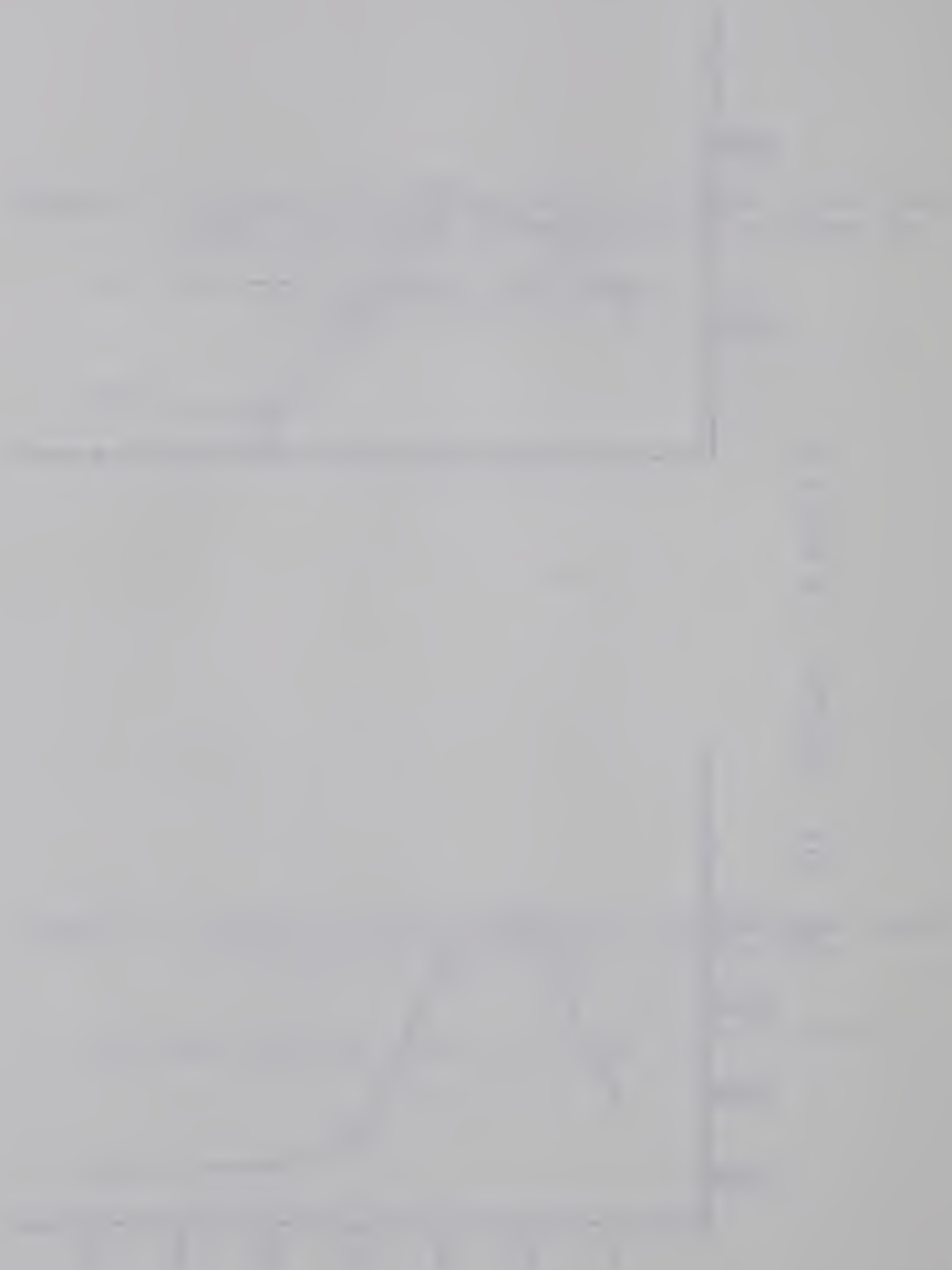


Figure 31 Seasonal variation in the lengths of walleye palatine teeth. All values are represented as in Figure 28.

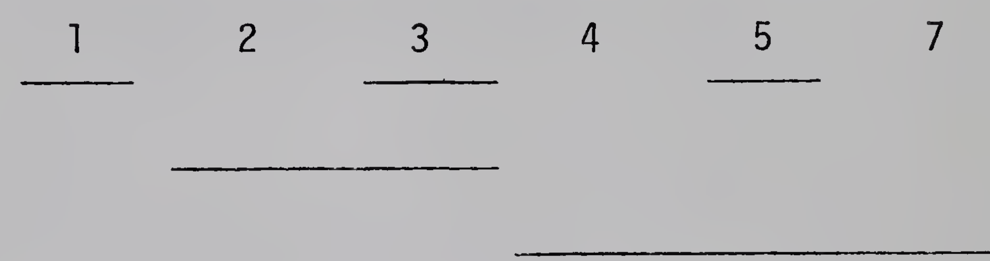
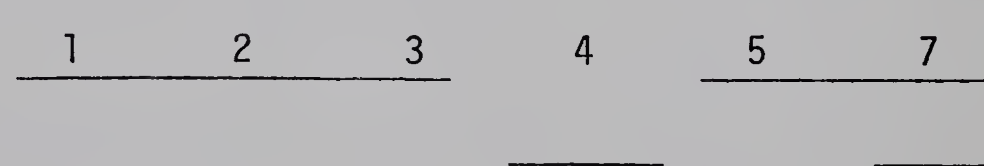
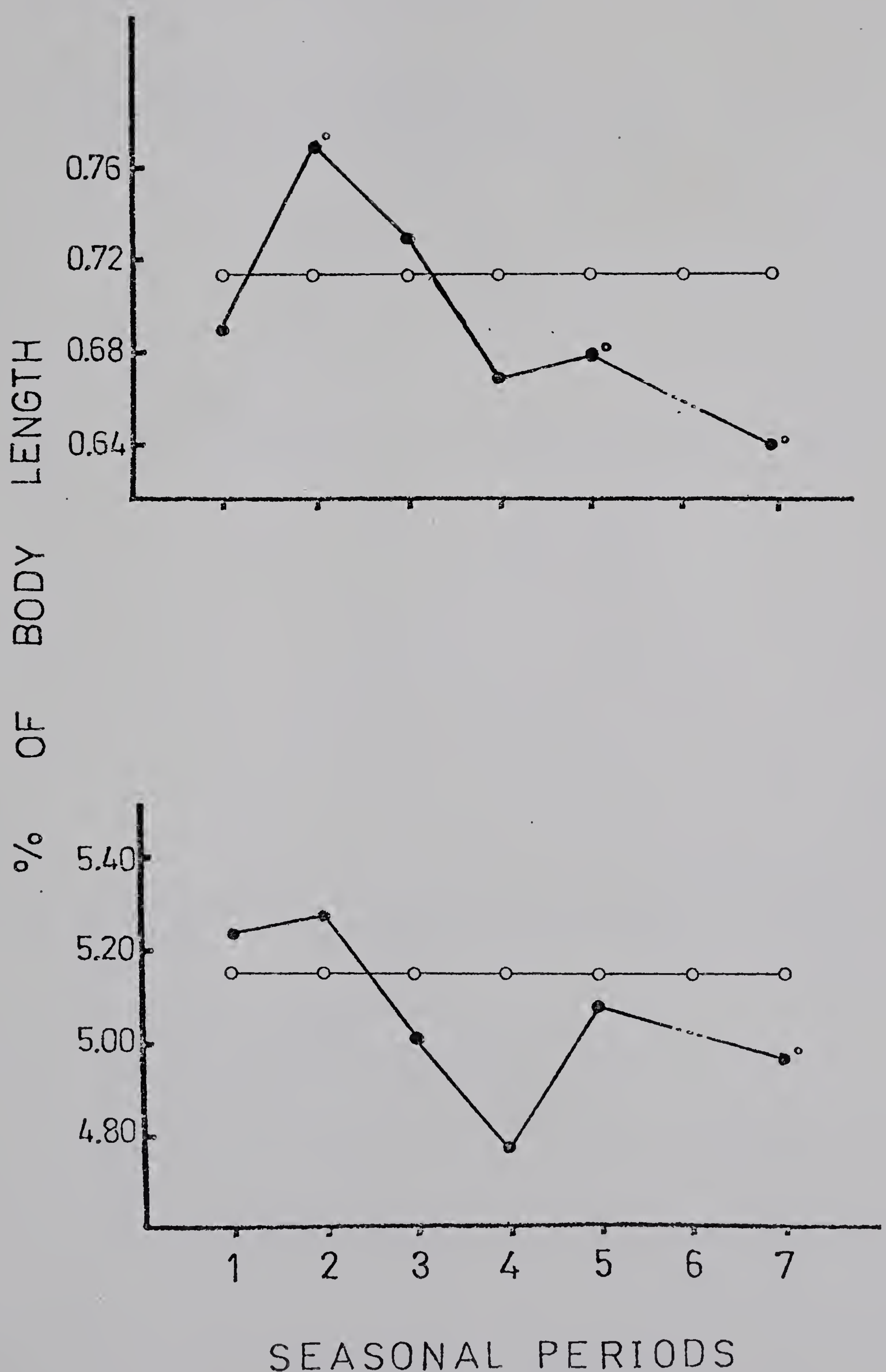
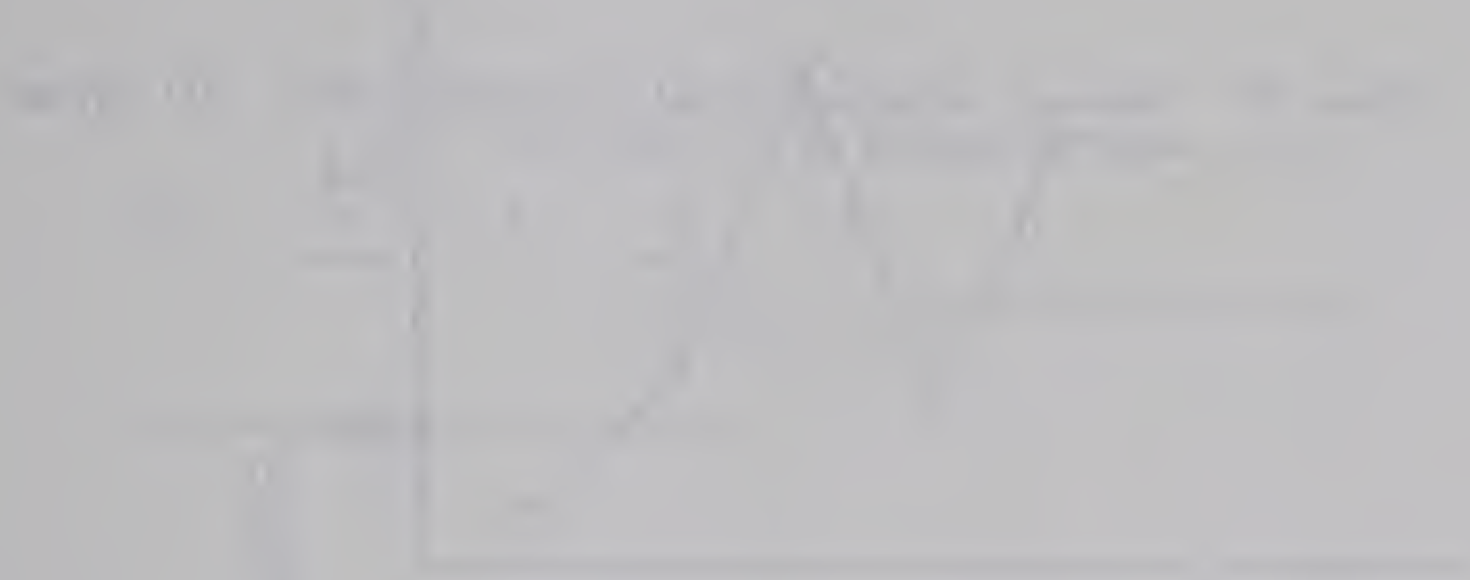


Figure 32 Seasonal variation in the lengths of walleye palatine toothed areas. All values are represented as in Figure 28.




% OF BODY LENGTH
0.76
0.72
0.68
0.64
5.40
5.20
5.00
4.80
1
2
3
4
5
6
7
SEASONAL PERIODS



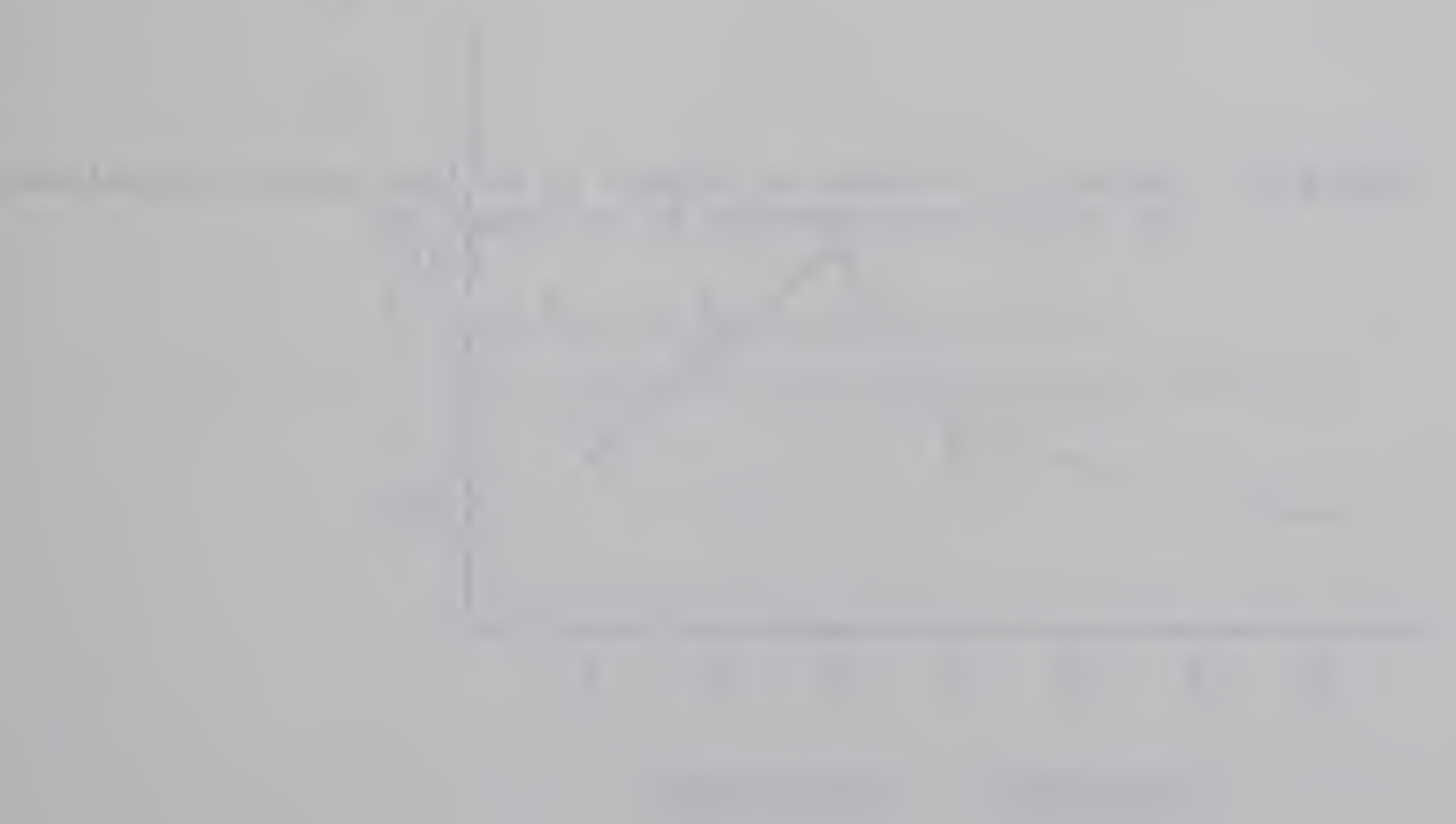


Figure 33 Seasonal variation in walleye mouth widths. All values are represented as in Figure 28.

1 2 3 4 5 7

Figure 34 Seasonal variation in lengths of walleye mouth indentations. All values are expressed as in Figure 28.

1 2 3 4 5 7

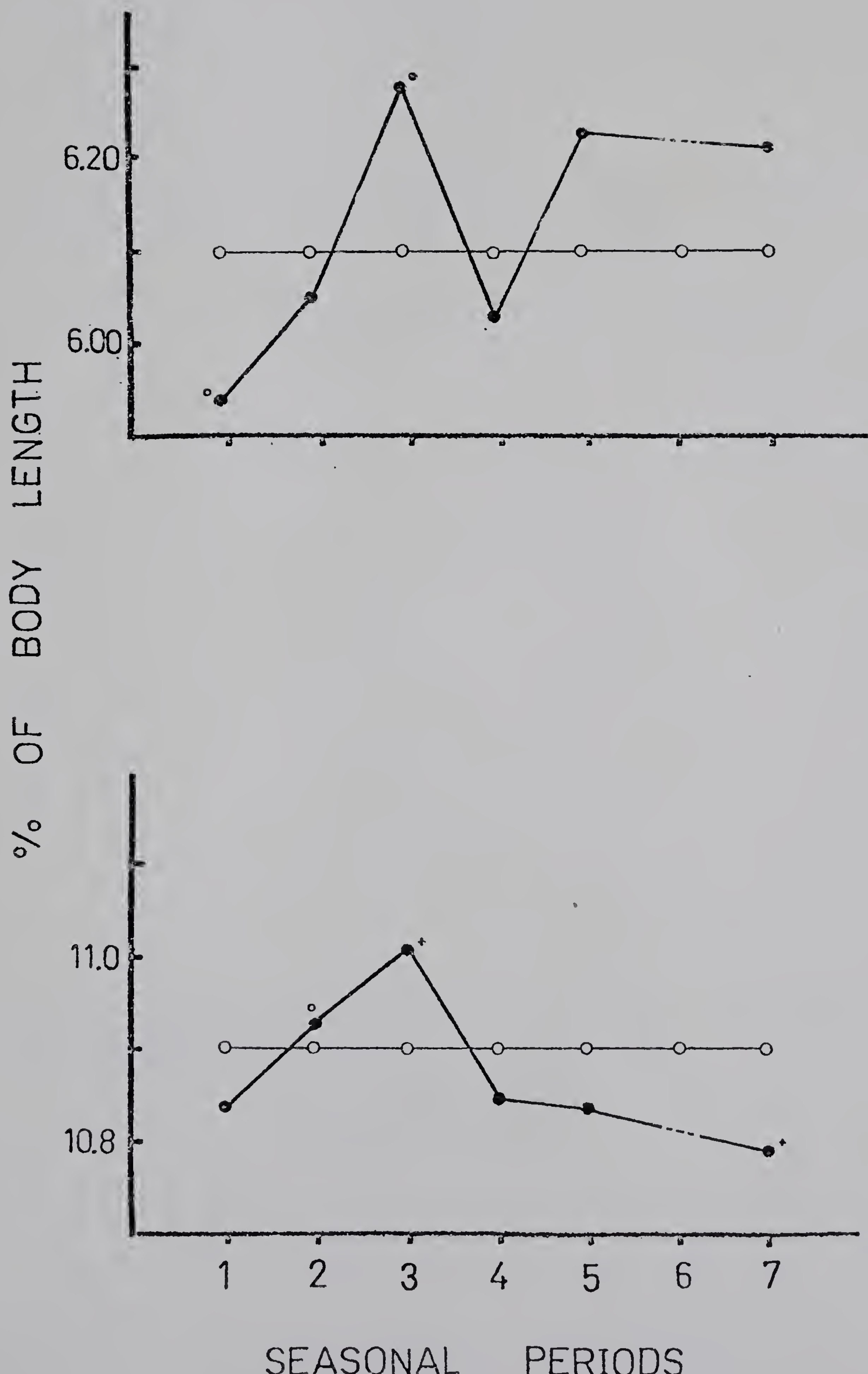

6.20
6.00
11.0
10.8
% OF BODY LENGTH
1 2 3 4 5 6 7
SEASONAL PERIODS

Figure 35 Seasonal variation in the lengths of walleye dentary toothed areas. All values are represented as in Figure 28.

1 2 3 4 5 7

Figure 36 Seasonal variation in the lengths of walleye premaxillary toothed areas. All values are represented as in Figure 28.

1 2 3 4 5 7

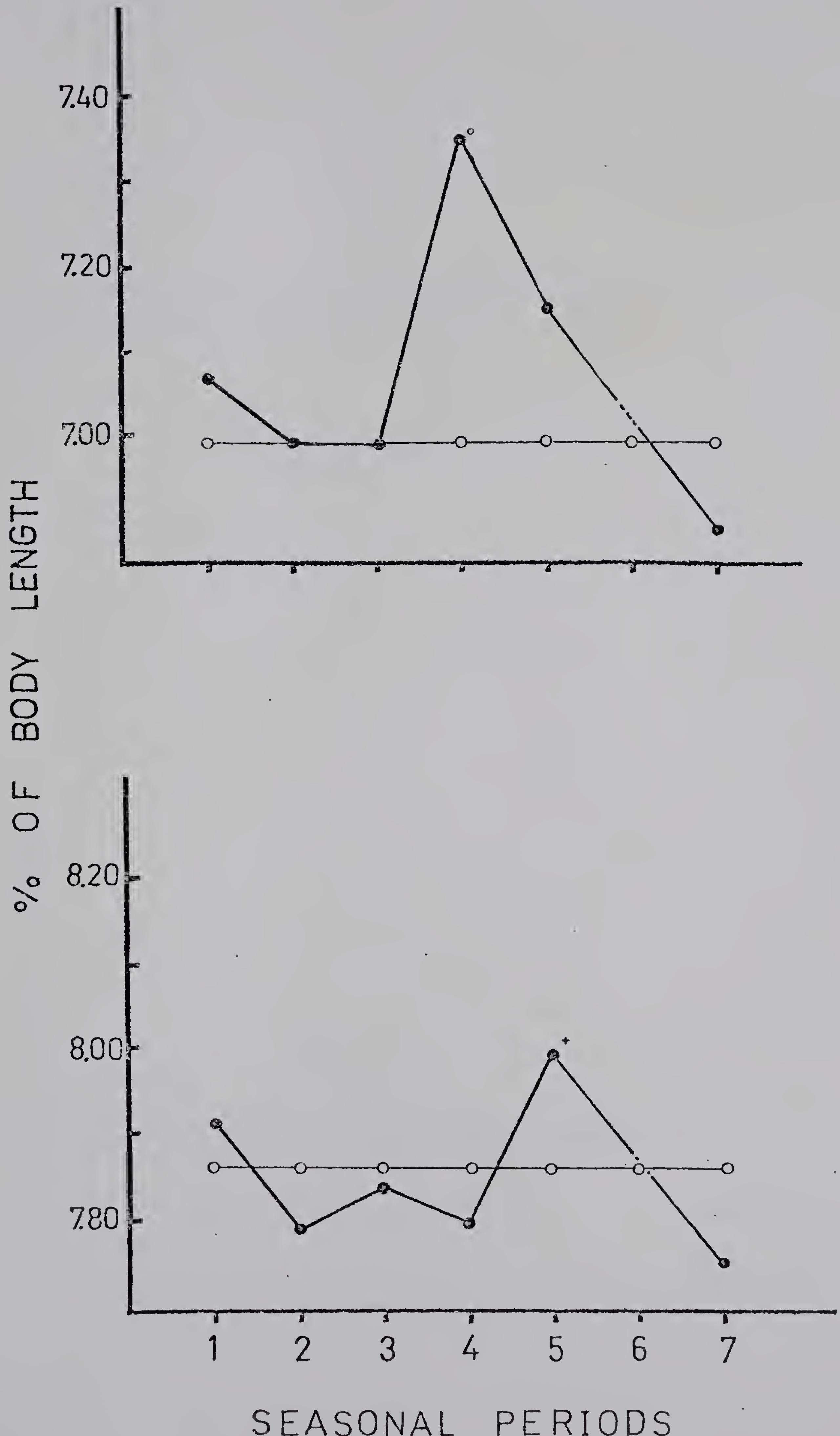

7.40
7.20
7.00
8.20
8.00
7.80
% OF BODY LENGTH
1
2
3
4
5
6
7
SEASONAL PERIODS

Figure 37 Seasonal variation in the lengths of walleye vomer toothed areas. All values are represented as in Figure 28.

1 2 3 4 5 7

Figure 38 Seasonal variation in walleye gill raker counts. All values are represented as in Figure 28.

1 2 3 4 5 7

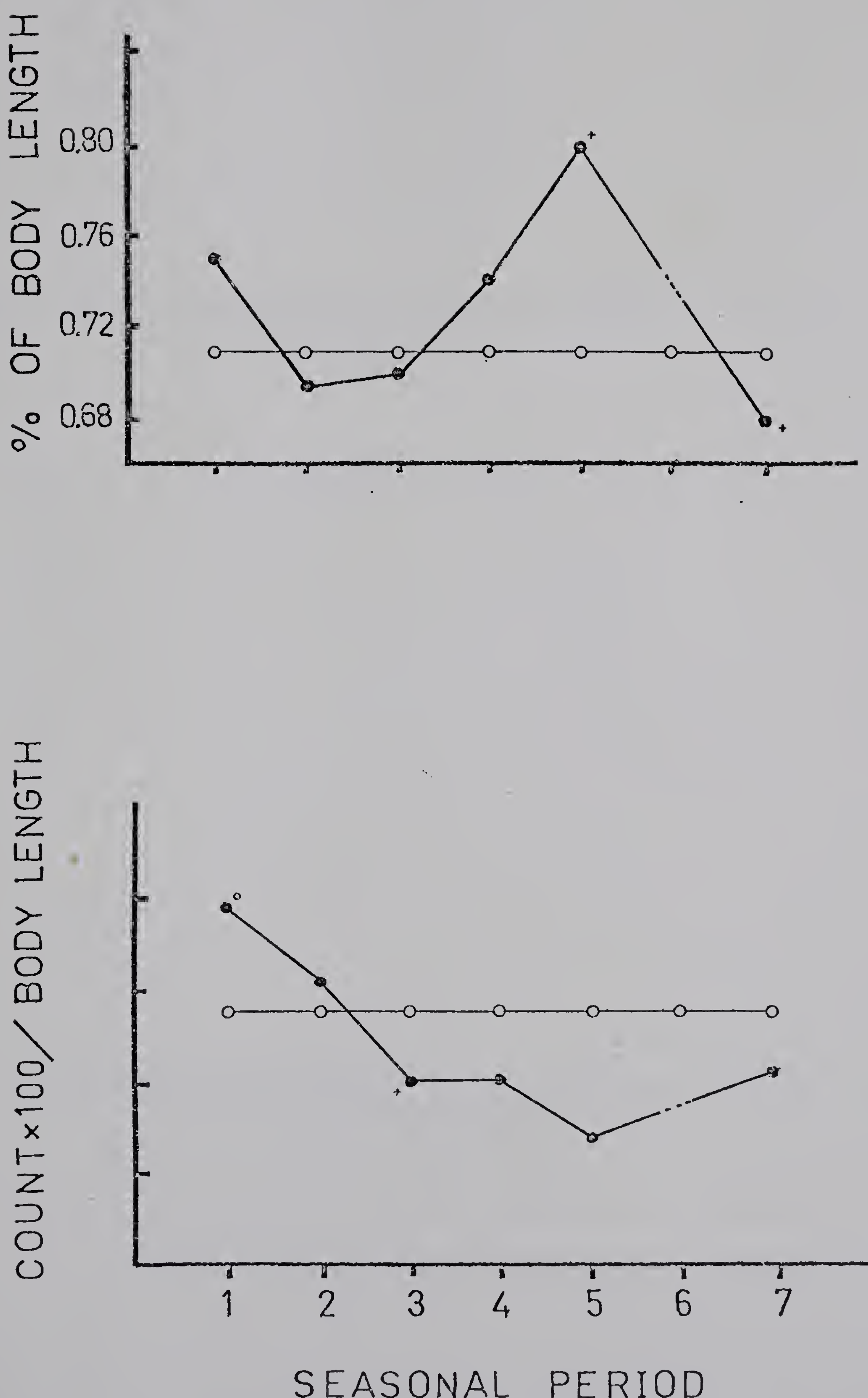
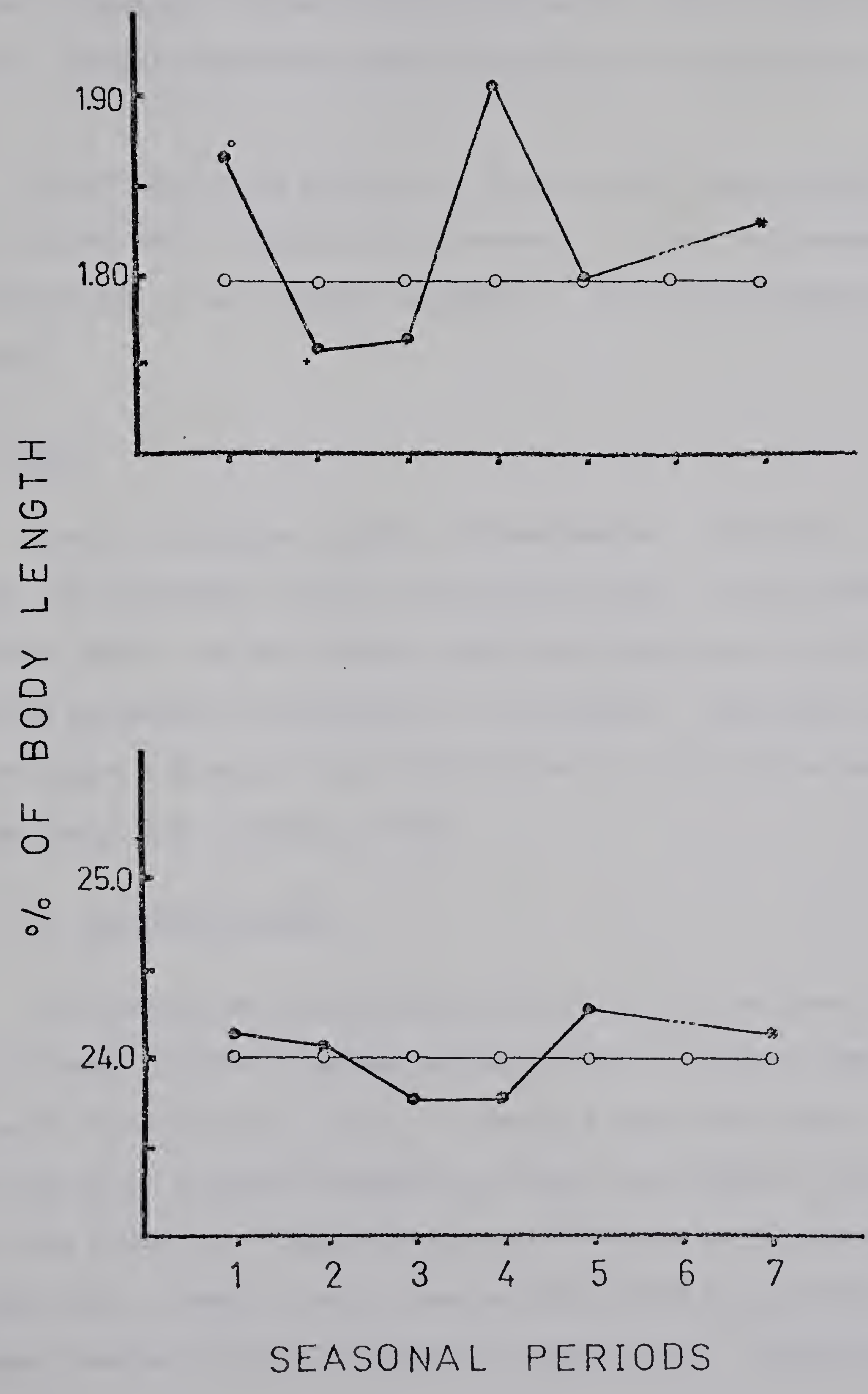

% OF BODY LENGTH
0.80
0.76
0.72
0.68
COUNT×100/ BODY LENGTH
1
2
3
4
5
6
7
SEASONAL PERIOD

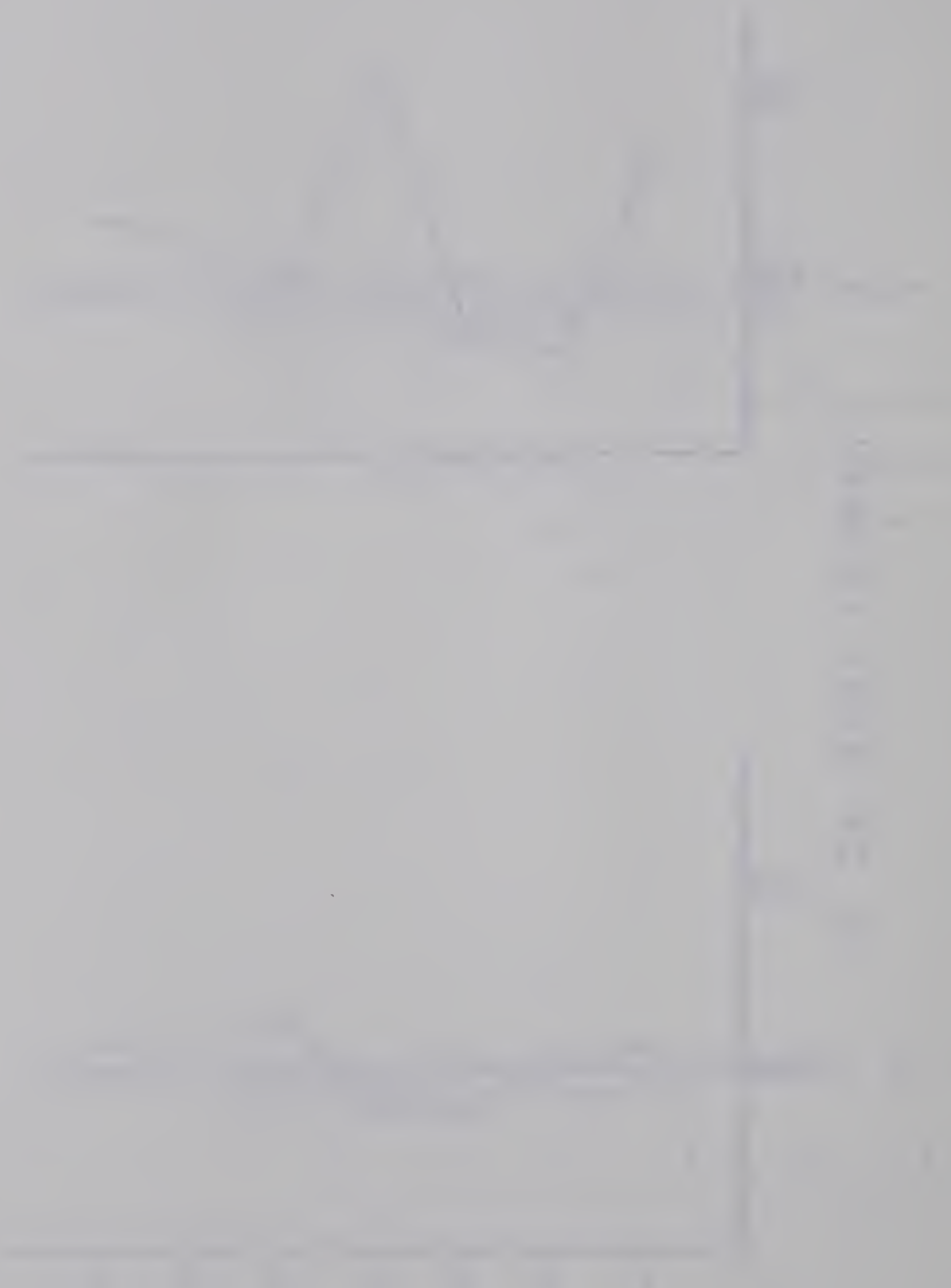
Figure 39 Seasonal variation in walleye gill raker lengths. All values are represented as in Figure 28.

1 2 3 4 5 7

Figure 40 Seasonal variation in walleye head lengths. All values are represented as in Figure 28.

1 2 3 4 5 7


1.90
1.80
25.0
24.0
% OF BODY LENGTH
1
2
3
4
5
6
7
SEASONAL PERIODS



caught per square metre of net per net set hour X 10^5) of each study area and bathymetric zone (Tables 3 to 6). The latter indicates where fish occur in greatest concentration but unlike the former it does not necessarily indicate where the greater proportion of the population occurs.

Unfortunately the division of the study into seven seasonal periods obscures short term population movements. Where such movements were detected but are not evident in Tables 3 - 6, they are mentioned in the text.

1. Perch

Perch distribution studies are numerous but results are variable. Sex [Eschmeyer, 1938], size [Hile and Juday, 1941], reproduction [Allen, 1935], and food [Hasler, 1945] play important roles in determining bathymetric distribution of this species. Temperature and dissolved oxygen influences their distribution in a less obvious manner [Hile and Juday, 1941; Ferguson, 1958].

(a) Area Distribution

Data pertaining to perch distribution in different areas (Table 3) shows that their greatest numbers occurred in Area I from spring until fall (Periods 1 to 3). In Period 4 perch were caught in all areas which indicates movement from Area I and dispersal throughout the lake (Table 3). Towards the spring (Periods 6 and 7) perch were found only in Areas II and III and on May 8, 1969 large numbers were found spawning in Area III (sampling station H17-1). Immediately

TABLE 3 Seasonal perch distribution in the three study areas given by relative number indices (fish/m^2/hour X lake area X 10^5) and relative density indices (fish/m^2/hour X 10^5).

	Lake Area	Seasonal Period						
		1	2	3	4	5	6	7
Relative Number	I	2128	98812	72354	71	53	0	0
	II	646	4323	4054	108	-	0	6583
	III	0	0	0	317	0	27	3390
Relative Density	I	241	3731	8196	8	6	0	0
	II	36	241	226	6	-	0	367
	III	0	0	0	15	0	1	128

after spawning, in the latter part of May and early June, perch were only caught in Area II possibly indicating a movement back to Area I where they congregated most of the previous year. This is not evident in Table 3 because all collections have been pooled for May and June (Period 7).

(b) Bathymetric Distribution

Perch preferred shallow shore areas in the spring but moved into deeper waters as the summer progressed (Table 4). In the fall they returned to shallower waters completing a pattern documented by Allen [1935] and Ferguson [1958]. During the winter (Periods 4, 5, and 6) perch collections were small but indicated a presence in the 2-4 m and >6 m depth zones. Ice formation of up to one metre in thickness would have excluded perch from the shallow water areas. In May (Period 7) the majority of perch were found in the 2-4 m depth zone. Collections did not continue into June to document a return to shallow water where they were found in Period 1.

2. Walleye

Studies of walleye distribution [Eschmeyer, 1950; Rawson, 1956; Forney, 1963] have shown that these fish exhibit similar seasonal distribution patterns in lakes throughout their range. In May, walleye concentrate on their spawning grounds and remain in shallow water areas for early summer feeding. During the summer they disperse widely into deeper waters and then return to shallower waters again in the fall. None of the authors have studied the winter distribution and behaviour of this species.

TABLE 4 Seasonal perch distribution in the four bathymetric zones given by relative number indices (fish/m^2/hour X zone area X 10^5) and relative density indices (fish/m^2/hour X 10^5).

	Depth Zone	Seasonal Period						
		1	2	3	4	5	6	7
Relative Number	0-2	1698	2614	1527	0	-	-	0
	2-4	0	1856	2541	55	33	0	3878
	4-6	0	4117	0	0	0	0	0
	> 6	0	0	0	523	0	22	480
Relative Density	0-2	189	291	170	0	-	-	0
	2-4	0	168	230	5	3	0	351
	4-6	0	361	0	0	0	0	0
	> 6	0	0	0	24	0	1	22

(a) Area Distribution

Walleye were mainly found in Areas II and III throughout the year (Table 5). During the open water months they seemed to range widely and were even caught in Area I during late July and August. In the winter, walleye were restricted to Area III (Table 5). During spawning in May, 1969, walleye were also restricted to Area III but this is not evident in Period 7 (Table 5) because in early June they were again caught in Area II indicating a return movement to their summer haunts.

(b) Bathymetric Distribution

During the summer the walleye is an active fish and exhibits great diurnal movement [Niemuth, Churchill, and Wirth, 1966]. Such behaviour can account for the appearance of walleye in all bathymetric zones during Periods 1, 2, and 3 although they were most dense in the 2-4 m depth zone (Table 6). During the day, walleye retreat to deeper water to avoid light and then move into shore areas during the night to feed [Eschmeyer, 1950]. Young of the year perch, their most common food item, were observed to concentrate in shore areas throughout the ice free season. Walleye appeared to occupy the bottom waters in depths greater than four metres because surface net sets could not catch them.

The winter distribution was restricted to the 2-4 m depth zone. During the formation of ice in November it was observed that young of the year perch migrated from the shallow waters into this depth

TABLE 5 Seasonal walleye distribution in the three study areas given by relative number indices as in Table 3.

	Lake Area	Seasonal Period						
		1	2	3	4	5	6	7
Relative Number	I	0	1051	0	0	0	0	0
	II	4323	13972	1256	0	-	0	5040
	III	12553	28523	11785	159	159	0	15915
Relative Density	I	0	119	0	0	0	0	0
	II	241	779	70	0	-	0	281
	III	474	1077	445	6	6	0	601

TABLE 6 Seasonal walleye distribution in the four bathymetric zones given by relative number indices as in Table 4.

	Depth Zone	Seasonal Period						
		1	2	3	4	5	6	7
Relative Number	0-2	4465	5319	2785	0	-	-	17213
	2-4	5723	11380	6475	44	188	0	6187
	4-6	3318	3615	3102	0	0	0	0
	> 6	5867	1352	1592	0	0	0	0
Relative Density	0-2	497	592	310	0	-	-	1916
	2-4	518	1030	586	4	17	0	560
	4-6	291	317	272	0	0	0	0
	> 6	269	62	73	0	0	0	0

zone. The main concentrations of walleye in Period 7 were found in shallow rocky areas where they were found spawning in May.

IV. DISCUSSION

This study further documents the phenomenon of seasonal diet changes correlated with changes in the feeding apparatus of fish as reported by Parker and Boseman [1954], Hardy [1959], and Luther [1962, 1964]. In Lac Ste. Anne, perch and walleye exhibited seasonal changes in the size of component parts of the feeding apparatus which were related to changes in seasonal intensity of feeding.

During May and June (Period 1), their dentition and mouth measurements increased in size prior to the warm months of most intensive feeding (Periods 2 and 3) then decreased to minimal sizes during the winter (Periods 4, 5 and 6) when food intake was greatly reduced. Although this pattern was the most general it did not encompass every mouth measurement and did vary seasonally between the species.

The phenomenon of seasonal tooth and gill raker change in other species is well documented by other studies [Chamber, 1934; Trautman and Hubbs, 1935; Parker and Boseman, 1954; Schwartz and Dutcher, 1962; Strasburg, 1963]. Certain species continually replace their teeth [Norris and Prescott, 1959; Strasburg, 1963] while others exhibit seasonal replacement [Schwartz and Dutcher, 1962; Strasburg, 1963]. If the replacement is continual or seasonal, replacement usually occurs in an orderly pattern so that fish will have functional teeth at all times [Trautman and Hubbs, 1935; Edmund, 1960]. Other authors have shown that this is not the case for some species which totally

replace teeth and gill raker processes during a season [Parker and Boseman, 1954; Strasburg, 1963; Luther, 1962, 1964]. In this study perch and walleye seemed to replace teeth seasonally yet maintained functional teeth throughout the year.

The teeth of walleye are characterized by single marginal teeth rows (Figures 6 and 7). Lower vertebrates which have such a dentition pattern commonly produce their teeth in lingual areas from which they migrate to the aveolar crest to be ankylosed and retained indefinitely [Edmund, 1960]. Edmund [1960] also reports that single rows of teeth undergo a synchronous row replacement from posterior lingual areas. Since mature teeth occupy the aveolar crest, the length of teeth in these single tooth rows, as measured in the walleye, can be considered a measurement of tooth maturity and the length of toothed areas as an indication of numbers and production of new teeth.

Thus, the walleye's new teeth proliferate (as indicated by increased toothed area lengths in Figures 32, 35, 36, and 37) during midwinter (Period 5), migrate to the aveolar crest during late winter and spring (Periods 6 and 7) and ankylose to become functional teeth in the summer and fall (Periods 2 and 3) when food intake is greatest. The intensive summer feeding can dislodge, damage, and dull these mature teeth. All damaged teeth are subsequently shed by basal osteoclastic reabsorption [Trautman and Hubbs, 1935; Norris and Prescott, 1959]. This would account for an overall reduction in tooth size found in walleye caught from Period 3 until May of Period 7. This decrease would be exaggerated by body length growth which would be disproportionately larger than tooth growth at that time of the year.

Edmund [1960] describes the marginal dentition pattern of the perch as a multiple row arrangement. Although the mature teeth appear on the alveolar crest, multiple row tooth production does not undergo the serial synchronous replacement evident in the walleye. Instead, tooth proliferation and replacement occurs randomly from adjoining lingual teeth [Edmund, 1960].

Thus as tooth size decreased in perch caught in Periods 1 to 3, immature replacements proliferated and the length of the toothed area increased as evident in Periods 1 and 2 (Figures 15, 17, 19 and 24). These immature replacements then moved to the aveolar crest and reached maturity during late winter and spring (Periods 6, 7 and 1) immediately prior to intensive feeding. Tooth maturity is indicated by tooth lengths and the longest teeth are considered most mature. Although both Period 1 and 7 represent spring, data from the two periods are not identical because Period 1 represents data from June, 1968 whereas Period 7 represents data primarily from May, 1969.

The seasonal change in gill rakers of perch and walleye was not similar to the pattern of change in dentition. The significant decrease in gill raker size during intensive feeding may have indicated rapid gill raker wear (Figures 26 and 39). Yasuda [1960a, 1960b] has shown that the gill rakers in piscivorous fishes are not an obvious functional part of the feeding apparatus. Nikolsky [1963] also notes that the gill rakers of the pike-perches and other highly piscivorous fish mainly protect the gills from food items.

Although the perch and walleye in this study did not consume plankton, other studies show that they do throughout their life cycle

[Langford and Martin, 1940; Priegel, 1963; Galbraith, 1967]. If the availability of larger food items is low, these versatile feeders can utilize planktors. Their armoured gill rakers would then serve a feeding and protective function.

Yasuda [1960a, 1960b] has shown that the mouth indentation of marine piscivores is analogous to the gill raker structure of plankton feeders in determining food types. Keast and Webb [1966] also emphasized the importance of mouth indentation for the predaceous mode of life. The mouth width determines the size of food items that can be swallowed and mouth indentation determines the grasping effectiveness of a predator [Yasuda, 1960]. It has been shown that similar fish with larger mouth widths can eat larger food organisms than fish with slightly smaller mouth widths [Northcote, 1954; Hartman, 1958]. The mouth width and indentation of the walleye (Figures 33 and 34) and the mouth indentation of the perch (Figure 21) exhibited maximal size during the period of intensive feeding. Prior to this period, jaw components would have grown disproportionately larger than body length. During greatest food uptake, the reverse would be the case and jaw components would decrease in size relative to body length. This phenomenon could be termed seasonal allometric growth.

It is most probable that this seasonal allometric growth enables perch and walleye to take maximum advantage of a short period of summer food abundance. Intensive summer feeding and associated growth is characteristic of temperate latitude fish [Varley, 1964; Nikolsky, 1963]. Langford and Martin [1940] have shown that the seasonal growth increment of Lake Mendota perch is dependent on a short period of

intensive summer feeding. A similar pattern has also been documented between feeding and growth of young walleye [Forney, 1966].

Although perch and walleye did feed most intensively during the summer, some food uptake occurred during the rest of the year. This would indicate that dentition and jaw structure was adequate for the amounts and types of food eaten during this non-intensive period of feeding. This would be expected since seasonal changes in the feeding apparatus were only distinguished by statistical methods and were not visually evident.

In this study it was postulated that perch and walleye distribution would depend on food location and their feeding apparatus would vary according to seasonal food type. The long seasonal periods, small sample sizes, and lack of food distribution data makes it impossible to prove that food distribution dictated perch and walleye distribution in Lac Ste. Anne at certain times of the year. Fish distribution can only be related to lake conditions (temperature, dissolved oxygen, and degree of eutrophication), spawning behaviour, and general food abundance.

Generally the food items preyed upon most would be expected to be found where the perch and walleye population numbers were greatest. The distribution of specific prey items can be related to the same lake areas where the fish were caught. For example plant material, leeches, and gastropods are predominantly found in littoral areas during the summer [Pennak, 1953] and fish caught in shore areas mainly ate these food types. Also the majority of walleye exploited young of the

year perch when they became available in Period 2. Most walleye were found in the shallower depth zones and it was only these that ate young perch. Observations from this study and others [Pearse, 1915; Pearse and Achtenburg, 1920] indicate that young perch live primarily in shore areas.

Many workers including Pearse and Achtenberg [1920], Keast [1965], and Parsons [1971] have shown that perch and walleye eat whatever food is most available. Varley [1964], and Nikolsky [1963] note that the availability of food usually dictates the diet of most temperate fresh water fishes. The variation in the food habits of both species studied makes it impossible to relate seasonal changes in mouth anatomy to the eating of specific food items.

Nikolsky [1969] noted that unstable environmental conditions in the North Temperate Zone accounts for polymorphism which is associated with the eurybiontic qualities of the fish of this zone. Within limits, almost any part of any fish endemic to this zone can undergo variation. Body parts which respond to environmental changes would be the most liable to change or adapt [Nikolsky, 1969]. Since food quality and quantity varies greatly with environmental changes, the feeding apparatus would be a body part most likely to vary and adapt to these changes.

SUMMARY

1. The feeding apparatus of the perch and walleye age classes studied exhibited 'ontogenetic isometric growth' when compared to body length.
2. Measurements of various components of the feeding apparatus of perch and walleye showed a seasonal change in size disproportionate to the changes in body lengths. This phenomenon can be termed 'seasonal allometric growth.'
3. Maximum 'seasonal allometric growth' of certain components of the feeding apparatus occurred prior to the maximal seasonal intake of food. Teeth, toothed areas, and mouth sizes were usually greatest at the onset of intensive feeding.
4. Perch and walleye usually fed upon the seasonally most abundant food organisms. In most cases the stomachs of both species contained food organisms expected to be found in the lake areas in which the fish were captured. Prey populations' numbers and distributions were not studied so no relationships can be drawn between them and stomach contents.
5. Seasonal variation in the size of the feeding apparatus was not dependent upon the individual types of food organisms consumed.
6. Perch and walleye seasonal distribution was not singly dependent upon food organism distribution.

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APPENDIX TABLE 1. Seasonal food of the walleye expressed by weight (grams) percentage of total weight, number, and percentage frequency occurrence for each seasonal period. The percentage frequency occurrence is also shown for each lake area and bathymetric zone. Sample size is indicated in Appendix Table 4.

WALLEYE PERIOD ONE MAY-JUNE 1968

STOMACH-CONTENTS	TOTAL WEIGHT OF CONTENTS	% OF TOTAL (G) WEIGHT	% FREQUENCY OCCURANCE		% OF EACH FOOD TYPE FOUND AT EACH DEPTH				IN EACH AREA		
			NO.	%	ZERO TO 2M	2+ TO 4M	4+ TO 6M	OVER 6M	ONE	TWO	THREE
EMPTY			25	71.43	20.00	44.00	36.00			28.00	72.00
PLANT MATERIAL											
PERCH ZERO YRS	6.20	10.01	3	8.57		33.33	66.67				100.00
PERCH 1 YRS +	9.32	15.04	2	5.71		100.00					100.00
UNID. FISH	12.28	19.82	6	17.14	33.33	50.00	16.67				100.00
SHINERS	3.25	5.25	1	2.86		100.00					100.00
BURBOT											
WHITEFISH	30.20	48.75	1	2.86		100.00					100.00
LEECHES	.70	1.13	2	5.71	50.00	50.00					100.00
DIPTERA PUPAE											
DIPTERA LARVAE											
TOTALS (G)	61.95	100.00									

WALLEYE PERIOD TWO JULY-AUGUST 1968

STOMACH-CONTENTS	TOTAL WEIGHT OF CONTENTS	% OF TOTAL (G) WEIGHT	% FREQUENCY OCCURANCE		% OF EACH FOOD TYPE FOUND AT EACH DEPTH				IN EACH AREA		
			NO.	%	ZERO TO 2M	2+ TO 4M	4+ TO 6M	OVER 6M	ONE	TWO	THREE
EMPTY			17	29.82	41.18	52.94	5.88			23.53	76.47
PLANT MATERIAL	2.43	1.79	4	7.02	50.00	50.00				50.00	50.00
PERCH ZERO YRS	69.96	51.64	24	42.11	20.83	66.67	8.33	4.17	8.33	37.50	54.17
PERCH 1 YRS +	18.44	13.61	6	10.53	16.67	83.33				66.67	33.33
UNID. FISH	32.34	23.87	31	54.39	19.35	67.74	9.68	3.23	9.68	51.61	38.71
SHINERS	9.04	6.67	3	5.26			66.67	33.33	66.67		33.33
BURBOT											
WHITEFISH	2.14	1.58	1	1.75		100.00					100.00
LEECHES											
DIPTERA PUPAE											
DIPTERA LARVAE	1.13	.83	1	1.75	100.00						100.00
TOTALS (G)	135.48	95.59									

APPENDIX TABLE 1 (continued)

WALLEYE PERIOD THREE SEPT-OCT 1968

STOMACH-CONTENTS	TOTAL WEIGHT OF CONTENTS	% OF TOTAL (G) WEIGHT	% FREQUENCY OCCURANCE NO.	%	% OF EACH FOOD TYPE FOUND AT EACH DEPTH ZERO TO 2M	2+ TO 4M	4+ TO 6M	OVER 6M	IN EACH AREA ONE	TWO	THREE
EMPTY			8	22.22	25.00	25.00	37.50	12.50			100.00
PLANT MATERIAL	1.24	1.05	3	8.33		66.67	33.33				100.00
PERCH ZERO YRS	56.01	47.57	19	52.78	31.58	21.05	47.37			10.53	89.47
PERCH 1 YRS +	28.77	24.44	5	13.89	20.00	20.00	60.00				100.00
UNID. FISH	16.52	14.03	15	41.67	26.67	33.33	40.00				100.00
SHINERS	10.85	9.22	3	8.33		33.33	66.67				100.00
BURBOT	3.85	3.27	3	8.33	33.33	66.67					100.00
WHITEFISH											
LEECHES											
DIPTERA PUPAE											
DIPTERA LARVAE	.49	.42	1	2.78		100.00					100.00
TOTALS (G)	117.73	100.00									

WALLEYE PERIOD FOUR NOV-DEC 1968

STOMACH-CONTENTS	TOTAL WEIGHT OF CONTENTS	% OF TOTAL (G) WEIGHT	% FREQUENCY OCCURANCE NO.	%	% OF EACH FOOD TYPE FOUND AT EACH DEPTH ZERO TO 2M	2+ TO 4M	4+ TO 6M	OVER 6M	IN EACH AREA ONE	TWO	THREE
EMPTY			3	75.00		100.00					100.00
PLANT MATERIAL											
PERCH ZERO YRS											
PERCH 1 YRS +											
UNID. FISH	.10	100.00	1	25.00		100.00					100.00
SHINERS											
BURBOT											
WHITEFISH											
LEECHES											
DIPTERA PUPAE											
DIPTERA LARVAE											
TOTALS (G)	.10	100.00									

WALLEYE PERIOD FIVE JAN-FEB 1969

STOMACH-CONTENTS	TOTAL WEIGHT OF CONTENTS	% OF TOTAL (G) WEIGHT	% FREQUENCY OCCURANCE NO.	%	% OF EACH FOOD TYPE FOUND AT EACH DEPTH ZERO TO 2M	2+ TO 4M	4+ TO 6M	OVER 6M	IN EACH AREA ONE	TWO	THREE
EMPTY			6	75.00		100.00					100.00
PLANT MATERIAL											
PERCH ZERO YRS	.51	20.65	1	12.50		100.00					100.00
PERCH 1 YRS +											
UNID. FISH	1.96	79.35	1	12.50		100.00					100.00
SHINERS											
BURBOT											
WHITEFISH											
LEECHES											
DIPTERA PUPAE											
DIPTERA LARVAE											
TOTALS (G)	2.47	100.00									

APPENDIX TABLE 1 (continued)

WALLEYE PERIOD SEVEN MAY-JUNE 1969

STOMACH-CONTENTS	TOTAL WEIGHT OF CONTENTS	% OF TOTAL (G) WEIGHT	% FREQUENCY OCCURANCE NO.	%	% OF EACH FOOD TYPE FOUND AT EACH DEPTH ZERO TO 2M	2+ TO 4M	4+ TO 6M	OVER 6M	IN EACH AREA ONE	TWO	THREE
EMPTY			16	69.57	31.25	68.75				12.50	87.50
PLANT MATERIAL											
PERCH ZERO YRS	2.15	9.81	2	8.70	50.00	50.00				50.00	50.00
PERCH 1 YRS +	15.08	68.83	2	8.70		100.00				50.00	50.00
UNID. FISH	.53	2.42	1	4.35		100.00				100.00	
SHINERS											
BURBOT											
WHITEFISH											
LEECHES											
DIPTERA PUPAE	4.15	18.94	3	13.04		100.00					100.00
DIPTERA LARVAE											
TOTALS (C)	21.91	100.00									

APPENDIX TABLE 2 Seasonal food habits of the perch expressed as in Appendix Table 1. Sample size is indicated in Appendix Table 3.

PERCH PERIOD ONE MAY-JUNE 1968

STOMACH-CONTENTS	TOTAL WEIGHT OF CONTENTS	% OF TOTAL (G) WEIGHT	% FREQUENCY OCCURANCE NO.	%	% OF EACH FOOD TYPE FOUND AT EACH DEPTH ZERO TO 2M	2+ TO 4M	4+ TO 6M	OVER 6M	IN EACH AREA ONE	TWO	THREE
EMPTY			1	20.00		100.00			100.00		
PLANT MATERIAL	.01	1.10	1	20.00	100.00					100.00	
PERCH											
AMPHIPODS	.68	74.73	4	80.00	100.00				50.00	50.00	
UNID. FISH											
CADDISFLY P.											
CADDISFLY L.	.14	15.38	2	40.00	100.00					100.00	
GASTROPODS	.08	8.79	1	20.00	100.00				100.00		
LEECHES											
DIPTERAN P.											
DIPTERAN L.											
TOTALS (C)	.91	100.00									

APPENDIX TABLE 2 (continued)

PERCH PERIOD TWO JULY-AUGUST 1968

STOMACH-CONTENTS	TOTAL WEIGHT OF CONTENTS	% OF TOTAL (G) WEIGHT	% FREQUENCY OCCURANCE NO.	%	% OF EACH FOOD TYPE FOUND AT EACH DEPTH ZERO TO 2M	2+ TO 4M	4+ TO 6M	OVER 6M	IN EACH AREA ONE	TWO	THREE
EMPTY			15	40.54	6.67	60.00	33.33		33.33	66.67	
PLANT MATERIAL	.23	.98	3	8.11	66.67	33.33				100.00	
PERCH	.78	3.33	1	2.70		100.00				100.00	
AMPHIPODS	6.75	28.78	6	16.22	66.67	33.33			16.67	83.33	
UNID. FISH	4.08	17.40	4	10.81	25.00		75.00		100.00		
CADDISFLY P.											
CADDISFLY L.	2.66	11.34	3	8.11	100.00				100.00		
GASTROPODS	1.96	8.36	5	13.51	60.00	40.00			100.00		
LEECHES	.01	.04	1	2.70		100.00				100.00	
DIPTERAN P.	6.89	29.38	10	27.03		10.00	90.00		90.00	10.00	
DIPTERAN L.	.09	.38	2	5.41		50.00	50.00		50.00	50.00	
TOTALS (G)	23.45	99.99									

PERCH PERIOD THREE SEPT-OCT 1968

STOMACH-CONTENTS	TOTAL WEIGHT OF CONTENTS	% OF TOTAL (G) WEIGHT	% FREQUENCY OCCURANCE NO.	%	% OF EACH FOOD TYPE FOUND AT EACH DEPTH ZERO TO 2M	2+ TO 4M	4+ TO 6M	OVER 6M	IN EACH AREA ONE	TWO	THREE
EMPTY			7	41.18	42.86	57.14			57.14	42.86	
PLANT MATERIAL	.36	8.99	1	5.88	100.00					100.00	
PERCH	.78	19.26	1	5.88	100.00					100.00	
AMPHIPODS	1.54	38.02	8	47.06	62.50	37.50			37.50	62.50	
UNID. FISH	.78	19.26	1	5.88	100.00					100.00	
CADDISFLY P.											
CADDISFLY L.	.16	3.95	1	5.88	100.00					100.00	
GASTROPODS	.12	2.96	1	5.88	100.00					100.00	
LEECHES											
DIPTERAN P.	.02	.49	2	11.76		100.00			100.00		
DIPTERAN L.	.29	7.16	5	29.41	40.00	60.00			60.00	40.00	
TOTALS (G)	4.05	99.99									

PERCH PERIOD FOUR NOV-DEC 1968

STOMACH-CONTENTS	TOTAL WEIGHT OF CONTENTS	% OF TOTAL (G) WEIGHT	% FREQUENCY OCCURANCE NO.	%	% OF EACH FOOD TYPE FOUND AT EACH DEPTH ZERO TO 2M	2+ TO 4M	4+ TO 6M	OVER 6M	IN EACH AREA ONE	TWO	THREE
EMPTY			13	68.42		7.69		92.31	7.69		92.31
PLANT MATERIAL											
PERCH											
AMPHIPODS	.09	18.00	2	10.53		100.00			100.00		
UNID. FISH	.41	82.00	4	21.05				100.00	25.00		75.00
CADDISFLY P.											
CADDISFLY L.											
GASTROPODS											
LEECHES											
DIPTERAN P.											
DIPTERAN L.											
TOTALS (G)	.50	100.00									

APPENDIX TABLE 2 (continued)

PERCH PERIOD FIVE JAN-FEB 1969

STOMACH-CONTENTS	TOTAL WEIGHT OF CONTENTS	% OF TOTAL (G) WEIGHT	% FREQUENCY OCCURANCE NO.	%	% OF EACH FOOD TYPE FOUND AT EACH DEPTH ZERO TO 2M	2+ TO 4M	4+ TO 6M	OVER 6M	IN EACH AREA ONE	TWO	THREE
EMPTY			1	25.00			100.00				100.00
PLANT MATERIAL											
PERCH	.87	43.50	1	25.00			100.00				100.00
AMPHIPODS											
UNID. FISH	.29	14.50	1	25.00		100.00				100.00	
CADDISFLY P.											
CADDISFLY L.											
GASTROPODS											
LEECHES											
DIPTERAN P.											
DIPTERAN L.	.84	42.00	1	25.00		100.00			100.00		
TOTALS (G)	2.00	100.00									

PERCH PERIOD SIX MAR-APR 1969

STOMACH-CONTENTS	TOTAL WEIGHT OF CONTENTS	% OF TOTAL (G) WEIGHT	% FREQUENCY OCCURANCE NO.	%	% OF EACH FOOD TYPE FOUND AT EACH DEPTH ZERO TO 2M	2+ TO 4M	4+ TO 6M	OVER 6M	IN EACH AREA ONE	TWO	THREE
EMPTY											
PLANT MATERIAL											
PERCH	1.66	100.00	1	100.00				100.00			100.00
AMPHIPODS											
UNID. FISH											
CADDISFLY P.											
CADDISFLY L.											
GASTROPODS											
LEECHES											
DIPTERAN P.											
DIPTERAN L.											
TOTALS (G)	1.66	100.00									

PERCH PERIOD SEVEN MAY-JUNE 1969

STOMACH-CONTENTS	TOTAL WEIGHT OF CONTENTS	% OF TOTAL (G) WEIGHT	% FREQUENCY OCCURANCE NO.	%	% OF EACH FOOD TYPE FOUND AT EACH DEPTH ZERO TO 2M	2+ TO 4M	4+ TO 6M	OVER 6M	IN EACH AREA ONE	TWO	THREE
EMPTY			10	45.45		90.00		10.00			100.00
PLANT MATERIAL											
PERCH											
AMPHIPODS	.80	13.18	4	18.18		100.00				75.00	25.00
UNID. FISH											
CADDISFLY P.	.07	1.15	2	9.09		100.00				100.00	
CADDISFLY L.	3.01	49.59	7	31.82		100.00				100.00	
GASTROPODS	1.74	28.67	4	18.18		100.00				25.00	75.00
LEECHES											
DIPTERAN P.											
DIPTERAN L.	.45	7.41	8	36.36		100.00				37.50	62.50
TOTALS (G)	6.07	100.00									

APPENDIX TABLE 3 Sample size and variation in actual and standarized measurements of perch body parts. All measurements are in milimetres except gill raker counts.

BODY LENGTH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	262.0000	294.0000	275.0000	303.0000	305.0000	290.0000	312.0000
LOW	210.0000	212.0000	211.0000	232.0000	233.0000	290.0000	221.0000
SAMPLE SIZE	5.0000	37.0000	17.0000	19.0000	4.0000	1.0000	22.0000
AVERAGE	237.6000	258.6216	250.8235	268.7893	277.5000	290.0000	265.0454
% AVERAGE	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
% RANGE: HIGH	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
LOW	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
STANDARD DEVIATION	23.0719	19.2014	18.3149	16.3401	31.1609	0.0	21.2726
ERROR MEAN	10.3181	3.1567	4.4420	3.7487	15.5804	0.0	4.5353

HEAD LENGTH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	63.2000	76.1000	70.9000	75.5500	70.5000	68.9000	77.2000
LOW	53.0000	54.1500	53.5000	61.2000	58.6000	68.9000	54.1000
SAMPLE SIZE	5.0000	37.0000	17.0000	19.0000	4.0000	1.0000	22.0000
AVERAGE	58.5099	66.4283	63.3646	67.0341	66.5250	68.9000	66.9454
% AVERAGE	24.6637	25.6852	25.2657	24.9747	24.0404	23.7586	25.2532
% RANGE: HIGH	25.2981	26.6667	26.8560	28.7603	25.1502	23.7586	26.5038
LOW	24.1079	24.7260	23.8868	23.3212	23.1147	23.7586	23.4199
STANDARD DEVIATION	0.5802	0.5531	0.8092	1.2802	0.8518	0.0	0.8132
ERROR MEAN	0.2595	0.0909	0.1963	0.2937	0.4259	0.0	0.1734

MOUTH WIDTH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	13.9500	16.3000	14.7500	18.1000	18.2000	15.4000	17.0000
LOW	12.1500	10.4000	9.6000	11.0500	11.9500	15.4000	11.0000
SAMPLE SIZE	5.0000	37.0000	17.0000	19.0000	4.0000	1.0000	22.0000
AVERAGE	13.1000	13.4729	12.8529	14.1973	15.0875	15.4000	13.3500
% AVERAGE	5.5380	5.2046	5.1226	5.2733	5.4140	5.3103	5.0356
% RANGE: HIGH	5.8486	6.0784	5.7393	6.2630	5.9672	5.3103	5.9233
LOW	5.0195	4.5455	4.3359	4.4403	5.1288	5.3103	4.4649
STANDARD DEVIATION	0.3787	0.3849	0.3738	0.4135	0.3761	0.0	0.3817
ERROR MEAN	0.1694	0.0633	0.0907	0.0949	0.1881	0.0	0.0814

APPENDIX TABLE 3 (continued)

MOUTH INDENTATION	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	24.6000	29.4000	26.1500	28.2500	26.4500	25.3000	29.7000
LOW	19.1000	12.4000	13.5500	21.0500	21.2000	25.3000	20.2000
SAMPLE SIZE	5.0000	37.0000	17.0000	19.0000	4.0000	1.0000	22.0000
AVERAGE	21.9200	24.6026	22.6058	24.4236	23.9375	25.3000	25.0818
% AVERAGE	9.2252	9.4945	9.0267	9.0875	8.6472	8.7241	9.4559
% RANGE: HIGH	9.7143	10.1961	10.0389	9.7575	9.0987	8.7241	9.8643
LOW	8.7615	5.6109	5.1132	8.3883	8.4043	8.7241	8.9610
STANDARD DEVIATION	0.4168	0.7123	1.0867	0.4099	0.3256	0.0	0.2461
ERROR MEAN	0.1864	0.1171	0.2636	0.0940	0.1628	0.0	0.0525

GILL RAKER COUNT	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	11.0000	12.0000	12.0000	13.0000	10.0000	8.0000	13.0000
LOW	8.0000	7.0000	8.0000	7.0000	9.0000	8.0000	8.0000
SAMPLE SIZE	5.0000	37.0000	17.0000	19.0000	4.0000	1.0000	22.0000
AVERAGE	10.0000	9.4865	10.3529	10.0000	9.5000	8.0000	10.4091
% AVERAGE	4.2603	3.7003	4.1736	3.7498	3.4731	2.7586	3.9382
% RANGE: HIGH	5.0459	5.4299	5.6872	5.3719	4.2918	2.7586	4.7273
LOW	3.1128	2.5090	2.9091	2.4823	2.9508	2.7586	3.1373
STANDARD DEVIATION	1.2247	1.4264	1.3666	1.5986	0.5774	0.0	1.2596
ERROR MEAN	0.5477	0.2345	0.3315	0.3667	0.2887	0.0	0.2685

GILL RAKER MEAS.	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	2.9500	3.3333	3.7833	3.1667	3.1167	2.8667	3.2000
LOW	2.2667	2.2000	2.1000	2.3500	2.8500	2.8667	2.2500
SAMPLE SIZE	5.0000	37.0000	17.0000	19.0000	4.0000	1.0000	22.0000
AVERAGE	2.6500	2.6800	2.7020	2.7632	3.0000	2.8667	2.7636
% AVERAGE	1.1265	1.0420	1.0775	1.0294	1.0925	0.9885	1.0469
% RANGE: HIGH	1.3532	1.5083	1.4331	1.1846	1.2732	0.9885	1.3122
LOW	0.8651	0.8273	0.8965	0.8669	0.9344	0.9885	0.8249
STANDARD DEVIATION	0.1830	0.1336	0.1583	0.0858	0.1390	0.0	0.1204
ERROR MEAN	0.0819	0.0220	0.0384	0.0197	0.0695	0.0	0.0257

DENTARY LENGTH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	16.2000	17.9000	16.4000	17.6000	16.6000	16.0000	18.2000
LOW	12.1000	11.0000	11.0000	12.4000	13.1500	16.0000	12.3500
SAMPLE SIZE	5.0000	37.0000	17.0000	19.0000	4.0000	1.0000	22.0000
AVERAGE	13.9300	14.9297	13.9176	14.8605	15.1875	16.0000	15.3704
% AVERAGE	5.8566	5.7707	5.5420	5.5264	5.4818	5.5172	5.7950
% RANGE: HIGH	6.1832	6.4652	6.2121	6.3246	5.6438	5.5172	6.3910
LOW	5.4772	4.9814	4.9107	4.6828	5.3621	5.5172	5.1636
STANDARD DEVIATION	0.3252	0.3267	0.3167	0.3597	0.1187	0.0	0.3071
ERROR MEAN	0.1454	0.0537	0.0768	0.0825	0.0594	0.0	0.0655

APPENDIX TABLE 3 (continued)

DENTARY TEETH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	0.7518	0.7187	0.6885	0.7098	0.6358	0.6108	0.7117
LOW	0.5570	0.5032	0.5198	0.4547	0.5383	0.6108	0.5227
SAMPLE SIZE	5.0000	37.0000	17.0000	19.0000	4.0000	1.0000	22.0000
AVERAGE	0.6277	0.6228	0.5931	0.5912	0.5930	0.6108	0.6194
% AVERAGE	0.2666	0.2414	0.2370	0.2201	0.2148	0.2106	0.2342
% RANGE: HIGH	0.3449	0.2691	0.2602	0.2540	0.2310	0.2106	0.2691
LOW	0.2352	0.1989	0.2068	0.1960	0.1964	0.2106	0.2050
STANDARD DEVIATION	0.0453	0.0158	0.0170	0.0146	0.0145	0.0	0.0184
ERROR MEAN	0.0202	0.0026	0.0041	0.0034	0.0072	0.0	0.0039

PREMAX LENGTH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	15.5000	17.7500	15.9000	17.3500	16.6000	14.8000	17.3500
LOW	12.8000	5.3000	11.6500	12.5000	13.3000	14.8000	11.5000
SAMPLE SIZE	5.0000	37.0000	17.0000	19.0000	4.0000	1.0000	22.0000
AVERAGE	13.9100	14.7802	14.2882	14.9895	15.3250	14.8000	15.1568
% AVERAGE	5.8595	5.7145	5.6981	5.5784	5.5371	5.1034	5.7178
% RANGE: HIGH	6.0952	6.5385	6.1441	6.2873	5.7241	5.1034	6.4229
LOW	5.4772	2.0784	5.2510	5.0403	5.1311	5.1034	5.1538
STANDARD DEVIATION	0.2288	0.7162	0.2688	0.3591	0.2778	0.0	0.3523
ERROR MEAN	0.1023	0.1177	0.0652	0.0824	0.1389	0.0	0.0751

PREMAX TEETH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	0.6390	0.7088	0.7122	0.6943	0.6533	0.6298	0.7062
LOW	0.5714	0.5290	0.5267	0.5343	0.5402	0.6298	0.5008
SAMPLE SIZE	5.0000	37.0000	17.0000	19.0000	4.0000	1.0000	22.0000
AVERAGE	0.6017	0.6102	0.5907	0.5918	0.6079	0.6298	0.6153
% AVERAGE	0.2546	0.2366	0.2359	0.2206	0.2197	0.2172	0.2330
% RANGE: HIGH	0.2827	0.2664	0.2652	0.2660	0.2318	0.2172	0.2756
LOW	0.2327	0.1994	0.2147	0.1909	0.2142	0.2172	0.1926
STANDARD DEVIATION	0.0191	0.0171	0.0162	0.0161	0.0082	0.0	0.0233
ERROR MEAN	0.0085	0.0028	0.0039	0.0037	0.0041	0.0	0.0050

PALATINE LENGTH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	11.2000	11.9000	11.5500	11.9000	11.8500	11.4000	12.2000
LOW	7.5500	7.5000	7.7000	8.4000	8.2500	11.4000	7.8000
SAMPLE SIZE	5.0000	36.0000	17.0000	19.0000	4.0000	1.0000	22.0000
AVERAGE	8.8500	9.8694	9.5588	10.2374	10.7000	11.4000	10.2445
% AVERAGE	3.7071	3.8188	3.8055	3.8125	3.8408	3.9310	3.8553
% RANGE: HIGH	4.2748	4.6154	4.4291	4.6810	3.9716	3.9310	4.4961
LOW	3.4440	2.9310	3.2364	3.1939	3.5408	3.9310	3.3766
STANDARD DEVIATION	0.3368	0.3978	0.3788	0.4456	0.2039	0.0	0.3262
ERROR MEAN	0.1506	0.0663	0.0919	0.1022	0.1019	0.0	0.0696

APPENDIX TABLE 3 (continued)

PALATINE TEETH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	0.6210	0.6610	0.6260	0.6624	0.5944	0.6222	0.6414
LOW	0.4542	0.4037	0.4038	0.4292	0.5383	0.6222	0.4358
SAMPLE SIZE	5.0000	37.0000	17.0000	19.0000	4.0000	1.0000	22.0000
AVERAGE	0.5124	0.5387	0.5447	0.5117	0.5613	0.6222	0.5454
% AVERAGE	0.2160	0.2087	0.2173	0.1904	0.2042	0.2145	0.2062
% RANGE: HIGH	0.2370	0.2483	0.2452	0.2186	0.2330	0.2145	0.2551
LOW	0.1885	0.1758	0.1853	0.1669	0.1765	0.2145	0.1676
STANDARD DEVIATION	0.0213	0.0190	0.0188	0.0165	0.0238	0.0	0.0210
ERROR MEAN	0.0095	0.0031	0.0045	0.0038	0.0119	0.0	0.0045

VOMER LENGTH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	1.8500	2.3000	2.0500	1.9000	1.9500	2.1500	2.0000
LOW	1.0000	1.1500	1.0000	1.0500	1.1000	2.1500	1.0500
SAMPLE SIZE	5.0000	37.0000	17.0000	19.0000	4.0000	1.0000	22.0000
AVERAGE	1.4300	1.6819	1.5882	1.5500	1.5625	2.1500	1.5955
% AVERAGE	0.6008	0.6517	0.6362	0.5781	0.5617	0.7414	0.6026
% RANGE: HIGH	0.7061	0.9502	0.8097	0.7011	0.6393	0.7414	0.7414
LOW	0.4149	0.4110	0.3636	0.3832	0.3901	0.7414	0.3875
STANDARD DEVIATION	0.1121	0.1122	0.1322	0.0934	0.1178	0.0	0.0971
ERROR MEAN	0.0501	0.0185	0.0321	0.0214	0.0589	0.0	0.0207

VOMER TEETH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	0.5828	0.6612	0.5910	0.6417	0.6065	0.6084	0.6553
LOW	0.5070	0.4496	0.4774	0.4737	0.4293	0.6084	0.4815
SAMPLE SIZE	5.0000	37.0000	17.0000	19.0000	4.0000	1.0000	22.0000
AVERAGE	0.5375	0.5473	0.5320	0.5358	0.5384	0.6084	0.5640
% AVERAGE	0.2279	0.2121	0.2130	0.1995	0.1938	0.2098	0.2133
% RANGE: HIGH	0.2585	0.2499	0.2495	0.2296	0.2151	0.2098	0.2349
LOW	0.1965	0.1851	0.1802	0.1709	0.1817	0.2098	0.1859
STANDARD DEVIATION	0.0248	0.0132	0.0178	0.0168	0.0152	0.0	0.0146
ERROR MEAN	0.0111	0.0022	0.0043	0.0039	0.0076	0.0	0.0031

APPENDIX TABLE 4 Sample size and variation in actual and standarized measurements of walleye body parts expressed as in Appendix Table 3.

BODY LENGTH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	497.0000	518.0000	510.0000	481.0000	482.0000	0.0	525.0000
LOW	400.0000	401.0000	412.0000	462.0000	423.0000	0.0	415.0000
SAMPLE SIZE	35.0000	57.0000	36.0000	4.0000	8.0000	0.0	23.0000
AVERAGE	428.9426	438.7893	452.0833	468.2500	445.2500	0.0	456.1738
% AVERAGE	100.0000	100.0000	100.0000	100.0000	100.0000	0.0	100.0000
% RANGE: HIGH	100.0000	100.0000	100.0000	100.0000	100.0000	0.0	100.0000
LOW	100.0000	100.0000	100.0000	100.0000	100.0000	0.0	100.0000
STANDARD DEVIATION	26.1663	29.7996	24.8786	8.6168	20.9625	0.0	28.5339
ERROR MEAN	4.4229	3.9471	4.1464	4.3084	7.4114	0.0	5.9497

HEAD LENGTH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	120.9000	128.6000	124.1000	113.9000	116.3000	0.0	126.9000
LOW	94.8000	90.0000	78.1000	108.9000	99.5000	0.0	97.8000
SAMPLE SIZE	35.0000	57.0000	36.0000	4.0000	8.0000	0.0	23.0000
AVERAGE	103.4928	105.6504	107.4471	111.2750	108.0749	0.0	110.1347
% AVERAGE	24.1393	24.0748	23.7560	23.7652	24.2808	0.0	24.1472
% RANGE: HIGH	25.7229	26.1845	25.2711	24.0909	25.8629	0.0	25.9524
LOW	21.6889	22.3880	18.1655	23.4193	23.4118	0.0	22.8936
STANDARD DEVIATION	0.7224	0.6516	1.4057	0.2856	0.7177	0.0	0.7263
ERROR MEAN	0.1221	0.0863	0.2343	0.1428	0.2537	0.0	0.1514

MOUTH WIDTH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	35.1000	32.6000	35.4000	30.9000	32.7000	0.0	32.0000
LOW	22.9000	22.9000	24.5000	24.3000	24.4000	0.0	25.5000
SAMPLE SIZE	35.0000	55.0000	35.0000	4.0000	8.0000	0.0	23.0000
AVERAGE	25.4499	26.5753	28.3799	28.1750	27.6875	0.0	28.3304
% AVERAGE	5.9369	6.0473	6.2753	6.0265	6.2159	0.0	6.2176
% RANGE: HIGH	8.5610	6.6584	7.1179	6.6883	7.1868	0.0	6.8027
LOW	5.4897	5.0664	5.6444	5.0520	5.3664	0.0	5.5809
STANDARD DEVIATION	0.5154	0.3076	0.4136	0.6987	0.5558	0.0	0.2940
ERROR MEAN	0.0871	0.0415	0.0699	0.3494	0.1965	0.0	0.0613

APPENDIX TABLE 4 (continued)

MOUTH INCENTATION	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	55.7000	59.7000	57.1000	51.2000	52.4000	0.0	56.3000
LOW	42.4000	13.4000	42.8000	50.5000	45.7000	0.0	43.4000
SAMPLE SIZE	35.0000	57.0000	36.0000	4.0000	8.0000	0.0	23.0000
AVERAGE	46.4899	47.9613	49.7569	50.8000	48.2625	0.0	49.2521
% AVERAGE	10.8425	10.9267	11.0077	10.8516	10.8395	0.0	10.7990
% RANGE: HIGH	11.5062	13.6156	11.5592	11.0822	11.1422	0.0	11.3333
LOW	9.7111	3.1529	10.0000	10.5821	10.4911	0.0	10.2128
STANDARD DEVIATION	0.3205	1.1769	0.3876	0.2059	0.2210	0.0	0.2864
ERROR MEAN	0.0542	0.1559	0.0646	0.1030	0.0782	0.0	0.0597

GILL RAKER COUNT	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	11.0000	11.0000	11.0000	10.0000	10.0000	0.0	11.0000
LOW	8.0000	6.0000	7.0000	9.0000	7.0000	0.0	7.0000
SAMPLE SIZE	35.0000	57.0000	35.0000	4.0000	8.0000	0.0	23.0000
AVERAGE	9.3714	9.2456	9.1429	9.5000	8.6250	0.0	9.1304
% AVERAGE	2.1914	2.1165	2.0235	2.0301	1.9404	0.0	2.0125
% RANGE: HIGH	2.6506	2.6699	2.6253	2.1505	2.2321	0.0	2.6190
LOW	1.8182	1.4184	1.4344	1.8711	1.6018	0.0	1.5054
STANDARD DEVIATION	0.6897	1.0050	0.7724	0.5774	0.9161	0.0	0.8149
ERROR MEAN	0.1166	0.1331	0.1306	0.2887	0.3239	0.0	0.1699

GILL RAKER MEAS.	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	9.3667	10.6333	10.4000	9.4667	9.7667	0.0	10.3000
LOW	6.5667	5.8333	5.3000	8.4667	6.3667	0.0	6.5667
SAMPLE SIZE	35.0000	57.0000	35.0000	4.0000	8.0000	0.0	23.0000
AVERAGE	8.0124	7.7116	8.0057	8.9167	7.9917	0.0	8.3565
% AVERAGE	1.8681	1.7601	1.7666	1.9057	1.7997	0.0	1.8334
% RANGE: HIGH	2.1074	2.2153	2.1903	2.0491	2.2349	0.0	2.1159
LOW	1.4958	1.3437	1.1497	1.7671	1.3721	0.0	1.5271
STANDARD DEVIATION	0.1388	0.1935	0.2203	0.1334	0.2695	0.0	0.1820
ERROR MEAN	0.0235	0.0256	0.0372	0.0667	0.0953	0.0	0.0379

DENTARY LENGTH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	36.3000	39.3000	37.4000	35.2000	35.1000	0.0	36.8000
LOW	26.3000	23.8000	26.4000	33.5000	30.0000	0.0	24.0000
SAMPLE SIZE	35.0000	57.0000	36.0000	4.0000	8.0000	0.0	23.0000
AVERAGE	30.2713	30.6718	31.3402	34.4000	31.8250	0.0	31.3978
% AVERAGE	7.0651	6.9856	6.9319	7.3471	7.1503	0.0	6.8898
% RANGE: HIGH	8.0000	7.6908	7.4115	7.5699	7.5000	0.0	7.6087
LOW	6.2222	5.5220	6.3415	7.2511	6.5934	0.0	5.1064
STANDARD DEVIATION	0.3778	0.4458	0.3025	0.1512	0.2873	0.0	0.5022
ERROR MEAN	0.0639	0.0591	0.0504	0.0756	0.1016	0.0	0.1047

APPENDIX TABLE 4 (continued)

DENTARY TEETH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	3.4250	3.6750	3.5750	3.2000	3.0750	0.0	3.4500
LOW	2.2750	2.2000	2.1000	2.6500	2.5000	0.0	2.1250
SAMPLE SIZE	35.0000	57.0000	36.0000	4.0000	8.0000	0.0	23.0000
AVERAGE	2.7368	2.8928	2.8366	2.9000	2.7812	0.0	2.7283
% AVERAGE	0.6391	0.6595	0.6277	0.6189	0.6251	0.0	0.5988
% RANGE: HIGH	0.7781	0.8791	0.8125	0.6653	0.6693	0.0	0.7248
LOW	0.5211	0.5357	0.4646	0.5699	0.5495	0.0	0.5024
STANDARD DEVIATION	0.0636	0.0742	0.0717	0.0421	0.0392	0.0	0.0603
ERROR MEAN	0.0107	0.0098	0.0120	0.0211	0.0139	0.0	0.0126

PREMAX LENGTH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	49.6000	43.4000	42.2000	38.1000	39.5000	0.0	42.0000
LOW	28.4000	24.9000	29.4000	32.8000	33.2000	0.0	31.3000
SAMPLE SIZE	35.0000	57.0000	36.0000	4.0000	8.0000	0.0	23.0000
AVERAGE	33.9685	34.1639	35.4430	36.5250	35.7125	0.0	35.3608
% AVERAGE	7.9145	7.7910	7.8418	7.8004	8.0169	0.0	7.7582
% RANGE: HIGH	9.9799	9.4514	8.4565	8.2468	8.3259	0.0	8.3953
LOW	7.1000	5.8588	7.0843	7.0538	7.6888	0.0	7.0975
STANDARD DEVIATION	0.5039	0.5421	0.3423	0.5203	0.2483	0.0	0.3683
ERROR MEAN	0.0852	0.0718	0.0571	0.2601	0.0878	0.0	0.0768

PREMAX TEETH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	3.3000	3.5500	3.5750	2.7500	2.4000	0.0	3.3500
LOW	1.2500	1.2000	0.0285	1.7000	1.2000	0.0	1.4500
SAMPLE SIZE	35.0000	57.0000	36.0000	4.0000	8.0000	0.0	23.0000
AVERAGE	2.1343	2.3044	2.4355	2.2625	1.9500	0.0	2.0435
% AVERAGE	0.4972	0.5259	0.5388	0.4832	0.4370	0.0	0.4478
% RANGE: HIGH	0.6947	0.8148	0.7944	0.5952	0.5172	0.0	0.6442
LOW	0.2778	0.2899	0.0064	0.3656	0.2837	0.0	0.3118
STANDARD DEVIATION	0.0922	0.1160	0.1339	0.0944	0.0715	0.0	0.0797
ERROR MEAN	0.0156	0.0154	0.0223	0.0472	0.0253	0.0	0.0166

PALATINE LENGTH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	25.6000	34.3000	27.1000	22.9000	25.5000	0.0	33.9000
LOW	19.0500	18.7000	20.0000	21.8000	21.2000	0.0	18.8000
SAMPLE SIZE	33.0000	57.0000	36.0000	4.0000	8.0000	0.0	23.0000
AVERAGE	22.4530	23.0841	23.0930	22.3500	22.5875	0.0	22.5882
% AVERAGE	5.2429	5.2689	5.1116	4.7732	5.0741	0.0	4.9591
% RANGE: HIGH	5.8824	8.2651	6.1591	4.8817	5.6044	0.0	7.2903
LOW	4.7566	3.8797	4.4099	4.6882	4.6983	0.0	4.2286
STANDARD DEVIATION	0.3025	0.5648	0.3287	0.0803	0.2986	0.0	0.6577
ERROR MEAN	0.0527	0.0748	0.0548	0.0402	0.1056	0.0	0.1371

APPENDIX TABLE 4 (continued)

PALATINE TEETH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	3.8500	4.6000	4.6500	3.3000	3.4000	0.0	4.1500
LOW	2.1500	1.8750	2.4000	2.7500	2.8000	0.0	2.3500
SAMPLE SIZE	35.0000	57.0000	36.0000	4.0000	8.0000	0.0	23.0000
AVERAGE	2.9407	3.3868	3.2975	3.1125	3.0187	0.0	2.9120
% AVERAGE	0.6876	0.7721	0.7303	0.6646	0.6791	0.0	0.6396
% RANGE: HIGH	0.8881	1.0222	0.9748	0.6926	0.7944	0.0	0.9022
LOW	0.5011	0.4551	0.5369	0.5914	0.6264	0.0	0.5106
STANDARD DEVIATION	0.0954	0.1270	0.1262	0.0489	0.0558	0.0	0.0962
ERROR MEAN	0.0161	0.0168	0.0210	0.0244	0.0197	0.0	0.0201

VOMER LENGTH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	4.3000	4.8000	4.3000	4.4000	4.1000	0.0	3.7000
LOW	1.8000	1.9000	1.7000	2.9000	2.9000	0.0	2.1000
SAMPLE SIZE	35.0000	57.0000	35.0000	4.0000	8.0000	0.0	23.0000
AVERAGE	3.2171	3.0482	3.1743	3.4750	3.5250	0.0	3.0870
% AVERAGE	0.7509	0.6956	0.6995	0.7419	0.7952	0.0	0.6778
% RANGE: HIGH	1.0000	1.1566	0.9130	0.9462	0.9693	0.0	0.8390
LOW	0.4045	0.4492	0.3803	0.6277	0.6250	0.0	0.4468
STANDARD DEVIATION	0.1328	0.1218	0.1342	0.1463	0.1055	0.0	0.0925
ERROR MEAN	0.0224	0.0161	0.0227	0.0731	0.0373	0.0	0.0193

VOMER TEETH	MAY-JUN 68	JUL-AUG 68	SEP-OCT 68	NOV-DEC 68	JAN-FEB 69	MAR-APR 69	MAY-JUN 69
RANGE: HIGH	3.1500	5.2000	4.1000	2.5000	2.6000	0.0	3.4000
LOW	1.5000	1.5000	0.3200	2.3000	1.9000	0.0	1.4000
SAMPLE SIZE	33.0000	55.0000	36.0000	4.0000	6.0000	0.0	21.0000
AVERAGE	2.3136	2.7073	2.7061	2.4250	2.2667	0.0	2.2952
% AVERAGE	0.5389	0.6158	0.6004	0.5181	0.5062	0.0	0.5033
% RANGE: HIGH	0.7125	1.0176	0.9172	0.5411	0.5882	0.0	0.7391
LOW	0.3529	0.3319	0.0665	0.4946	0.3942	0.0	0.2979
STANDARD DEVIATION	0.0773	0.1262	0.1637	0.0247	0.0844	0.0	0.0979
ERROR MEAN	0.0135	0.0170	0.0273	0.0124	0.0345	0.0	0.0214

APPENDIX TABLE 5 Monthly temperatures (C) taken at various stations in Lac Ste. Anne as indicated by:

1. average of weekly temperatures taken at D18.
2. average of temperatures taken at H17 (Sept. 12) and D6 (Sept. 29, 1968).
3. average of temperatures taken at D18 (Nov. 3) and F18 (Nov. 11, 1968).
4. temperature at D16 on Dec. 16, 1968.
5. temperature at D18 on Jan. 3, 1969.
6. temperature at E5 on Feb. 15, 1969.
7. temperature at E5 on Feb. 15, 1969.
8. temperature at E18 on April 29, 1969.
9. temperature at D16 on May 8, 1969.

The period of ice cover lasted from November 11, 1968 to April 29, 1969.

	1968								1969				
Depth (Metres)	May[1]	June[1]	July[1]	Aug[1]	Sept[2]	Oct[1]	Nov[3]	Dec[4]	Jan[5]	Feb[6]	Mar[7]	Apr[8]	May[9]
Surface	12.3	16.1	21.7	18.6	14.0	6.3	3.7	0.0	0.4	1.0	0.0	0.9	7.1
1	12.3	16.1	20.2	18.4	14.1	6.3	3.5	1.2	1.0	2.0	0.0	4.2	6.8
2	12.1	15.6	19.9	18.0	13.8	6.4	3.4	1.4	1.6	3.3	1.3	4.6	6.6
3	11.3	15.3	19.5	18.0	14.1	6.3	3.5	1.7	2.1	4.0	2.4	4.6	6.3
4	11.1	15.1	19.1	17.9	13.7	6.3	3.3	1.9	2.7	4.6	2.8	4.4	6.3
5	11.1	14.8	18.6	17.8		6.3	3.5	2.0	3.2	4.8	3.2	4.5	5.4
6	9.9	14.2	17.4	17.8		6.7	3.7	3.8	4.0		3.7	4.7	5.4
7								3.2			3.9		5.4
8								3.8			4.8		5.3

Date	Station	Depth in Metres			
		1	2	4	7
Nov 24, 1968	C19-3	12.3	12.3		
Dec. 16	D16-4				8.4
Jan. 3, 1969	E18-3	10.9		7.9	
Feb. 8	E20-4		5.4	4.1	
Feb. 15	F5-1		4.4	2.1	
March 1	D16-4				2.9
March 30	D6-2		2.6	0.3	0.2
April 29	E18-3		4.9	3.0	

APPENDIX TABLE 6 Dissolved oxygen determinations (ppm) at various stations and depths. The values of April 29, 1969 were taken at the time of ice break-up.

	YEARS OF GROWTH							
	1	2	3	4	5	6	7	8
Average Fork Length (cm)	9.9	19.6	29.3	36.3	42.0	46.1	49.0	50.2
Fork Length Range (cm)	6.1-13.8	13.9-25.0	23.0-36.6	31.7-42.6	37.5-47.0	40.0-49.4	45.5-51.6	46.0-51.8

APPENDIX TABLE 7 Lac Ste. Anne walleye population growth based upon back-calculations of the scale growth of 46 adult walleye (fork length range 40.0 - 51.8 cm).

	YEARS OF GROWTH							
	1	2	3	4	5	6	7	8
Average Fork Length (cm)	9.3	13.0	17.1	20.1	23.1	25.2	26.8	27.6
Fork Length Range (cm)	8.1-10.0	11.0-13.9	14.5-18.8	18.5-21.5	21.0-24.2	24.4-26.8	26.0-28.5	27.0-28.1

APPENDIX TABLE 8 Lac Ste. Anne perch population growth based upon back calculations of opercular bone growth of 15 adult female perch (fork length range 21.2 - 29.4 cm).

Lake Area		SEASONAL PERIOD						
		1	2	3	4	5	6	7
I	Effort	1244	5628	122	48,036	33,316	68.069	1287
	Catch	3	21	10	4	2	0	0
II	Effort	5467	9133	3525	68,160	0	46,451	1906
	Catch	2	22	8	4	0	0	7
III	Effort	12,900	5658	11,334	100,703	179,476	124,056	11,717
	Catch	0	0	0	16	0	1	15
Total	Effort	19,611	20,419	14,981	216,899	212,792	238,576	14,910
Total	Catch	5	43	18	24	2	1	22

APPENDIX TABLE 9 Seasonal catch effort (m^2 net X hours set) and numbers of perch caught in each lake area.

Lake Area		SEASONAL PERIOD						
		1	2	3	4	5	6	7
I	Effort	898	4201	109	34,051	30,281	45,457	906
	Catch	0	5	0	0	0	0	0
II	Effort	3729	6544	2819	47,034	0	32,942	1424
	Catch	9	51	2	0	0	0	4
III	Effort	9895	5294	8300	68,656	129,015	86,310	8148
	Catch	47	57	37	4	8	0	49
Total	Effort	14,522	16,039	11,228	149,741	159,296	164,709	10,477
Total	Catch	56	113	39	4	8	0	53

APPENDIX TABLE 10 Seasonal catch effort (m^2 net X hours set) and number of walleye caught in each lake area.

Depth Zones (m)		SEASONAL PERIOD						
		1	2	3	4	5	6	7
0-2	Effort	2640	3431	4696	1117	0	0	2167
	Catch	5	10	8	0	0	0	0
2-4	Effort	5606	10,717	4337	141,392	65,250	46,730	5991
	Catch	0	18	10	7	2	0	21
4-6	Effort	8555	4155	4115	4278	126,524	48,982	2215
	Catch	0	15	0	0	0	0	0
> 6	Effort	2809	2116	1833	70,112	21,018	142,864	4538
	Catch	0	0	0	17	0	1	1
Total	Effort	19,610	20,419	14,981	216,899	212,792	238,576	14,910
Total	Catch	5	43	18	24	2	1	22

APPENDIX TABLE 11 Seasonal catch effort (m^2 net X hours set) and numbers of perch caught in in each depth zone.

Depth Zone (m)		SEASONAL PERIOD						
		1	2	3	4	5	6	7
0-2	Effort	2213	3207	3861	767	0	0	1566
	Catch	11	19	12	0	0	0	30
2-4	Effort	4242	8059	3071	98,799	46,250	33,186	4109
	Catch	22	83	18	4	8	0	23
4-6	Effort	5840	3158	2937	2992	93,702	36,117	1724
	Catch	17	10	8	0	0	0	0
> 6	Effort	2227	1615	1359	47,184	19,344	95,406	3079
	Catch	6	1	1	0	0	0	0
Total	Effort	14,522	16,039	11,228	149,741	159,296	164,709	10,477
Total	Catch	56	113	39	4	8	0	53

APPENDIX TABLE 12 Seasonal catch effort (m^2 net X hours set) and numbers of walleye caught in each depth zone.

			SEASONAL PERIODS						
			1	2	3	4	5	6	7
Perch	Age Years	Range	5-6	5-7	5-7	5-8	5-8	7	5-8
		Average	5.8	6.0	5.7	6.4	6.8	7	6.1
	Sex	Male	0	0	0	0	0	0	0
		Female	5	37	17	19	4	1	22
		Unsexed	0	0	0	0	0	0	0
Walleye	Age Years	Range	5-7	5-8	5-7	5-7	5-7	0	5-8
		Average	5.3	5.5	5.5	6.3	5.3	0	5.9
	Sex	Male	10	34	20	0	6	0	14
		Female	15	22	16	4	2	0	9
		Unsexed	10	1	0	0	0	0	0

APPENDIX TABLE 13 Sex and age composition of perch and walleye of the samples studied.

	Zone	Area in km^2	% of Study Area
Bathymetric Zones (m)	0-2	8.99	16.88
	2-4	11.05	20.75
	4-6	11.40	21.41
	> 6	21.81	40.96
	Total	53.25	100.00
Lake Areas	I	8.83	16.58
	II	17.94	33.69
	III	26.48	49.73
	Total	53.25	100.00

APPENDIX TABLE 14 Area relationships of Lac Ste. Anne considering bathymetric zones and lake areas. The most westerly basin of the lake has not been considered.